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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

POLONIUM–210 IN TOBACCO PRODUCTS AND HUMAN TISSUES

E. S. Ferri and *E. J. Baratta*[1]

Using a "smoking machine," tobacco smoke was collected. It was found that polonium–210 concentrations in the tobacco smoke accounted for about 11 to 30 percent of that found in the total product, depending on the type of filter used. Analyses of human tissues indicated that the lung, blood, and liver, in that order, of smokers contained more polonium–210 than the corresponding organs of nonsmokers.

The possibility that polonium–210 in tobacco may be implicated in the origin of lung cancer prompted studies on the levels of this and related radionuclides in several brands of cigarettes (*1*,*2*). To determine whether the polonium–210 was present independently or in equilibrium with its precursors, radium–226 and lead–210 levels were also measured. In addition, selected samples of human organs from smokers and nonsmokers were measured for polonium–210 concentrations to determine whether a difference could be detected due to smoking.

Products investigated

Various major tobacco product types chosen for the study included nonfiltered cigarettes, filtered cigarettes, and cigarettes containing tobacco treated for removal of tars and nicotine. Although normally considered a lesser health hazard to the lungs, cigars and pipe tobacco were also assayed for purposes of comparison.

Methodology of analysis

"Classical" separations were performed on tobacco ashed at 450°C. for the analysis of radium–226 and lead–210. Radium–226 was determined by emanation, collection, and counting the gaseous daughter, radon–222 (*3*). Lead–210 was isolated using an anion exchange resin, precipitated as a chromate, and the ingrown daughter, bismuth–210, counted. Lead–210 was also determined by collecting the bismuth–210 on an anion resin, eluting, precipitating as an oxychloride, and counting. Purity of recovery is ascertained by decay observations.

Because polonium–210 is volatile at dry ashing temperatures, samples were wet ashed with nitric and perchloric acids. The resulting solution was made 0.5*N* in hydrochloric acid, and the polonium–210 was spontaneously deposited on a silver disk (*4*). Purity and activity were observed on an alpha spectrometer.

All samples analyzed for polonium–210 were electroplated on silver disks from a hydrochloric acid solution. To evaluate the plating efficiency, a known amount of polonium–210 tracer was added to previously depleted samples. An average of 96.9 ± 3.6 percent plating efficiency was obtained. The recoveries from

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the various media demonstrated that there was no significant loss of polonium–210 during the plating process.

Results of analysis

Table 1 illustrates that the parent radium–226 is not in equilibrium with its daughters, lead–210, bismuth–210, and polonium–210. The high lead-to-radium ratios indicate that lead–210 independently reaches the plant via direct uptake from the soil and/or deposition from the precursor radon–222 in the air. The derivation of the lead–210, and consequently polonium–210, is uncertain. Marsden (*5*), using autoradiographic techniques to measure surface activities of tobacco leaves, has stated that polonium from fallout is minor compared to uptake from the soil through roots. Gregory (*6*) suggested that in insular or coastal growing areas the natural radon emanating from the soil was dispersed, resulting in lower concentration in that region.

Table 1. Radionuclides in tobacco products (cigarette, cigar, pipe tobacco)

Type	Radium-226	Lead-210	Polonium-210	Lead-210/radium-226
Cigarettes, pCi cigarette				
Nonfilter	0.15	0.44	0.43	2.9
Nonfilter	0.15	0.42	0.37	2.8
Filter				
Cellulose	0.17	0.33	0.32	1.9
Cellulose and charcoal	0.12	0.49	0.48	4.1
Cellulose, charcoal, treated	0.11	0.33	0.34	3.0
Cellulose, pipe tobacco	0.11	0.35	0.34	3.2
Cigars, pCi cigar				
5¼", 7.8 grams	0.74	3.55	3.60	4.0
Pipe tobacco, pCi/g				
Regular cut	0.10	0.41	0.20	4.3

The values for radium–226 and polonium–210 agree with those reported by Tso, Hallden, and Alexander, for various domestic tobaccos (*7*). All cigarettes and cigars show lead–210 and polonium–210 to be in equilibrium. This is probably the result of the approximate 2-year "aging" time employed in processing tobacco for cigars and cigarettes. The sample of pipe tobacco showed only about 50 percent equilibrium. This indicates the possibility that the brand chosen had been "cured" and "aged" a minimum length of time, and had been on the vendor's shelf for a short time.

Smoking machine

Of primary interest as a health hazard from smoking are those nuclides which are volatile at the temperature of burning tobacco. Before this hazard can be assessed, it is necessary to determine the levels of activity in the smoke, and thus inhaled and/or deposited in the mouth, bronchial tract, and lungs of the smoker.

To collect the smoke as normally inhaled, a smoking apparatus (shown schematically in figure 1) which simulates smoking, was devised and tested. The polonium–210 which has volatilized, and the nicotine and tars, are collected on two filters (glass wool, and 0.45μ Millipore) followed by a hydrochloric acid trap. To simulate puffing, the system is connected to a vacuum line and airflow is regulated by flowmeter, vacuum gauge, electronic timer, and solenoid valve. The smoking rate was set at 10 puffs per cigarette, with each puff of 3 seconds duration, and 26-second intervals between puffs. The average smoke flow rate was 18 ml/second (at standard conditions of temperature and pressure). Sidestream smoke is collected by placing a bottle over the burning cigarette, and a filter, connected to a vacuum line, is attached to the bottle. Thus, when smoke is not being drawn through the cigarette, it collects on the filter in the flask.

A comparison was made between the butts and ashes obtained from filters, nonfilters, and treated-tobacco cigarettes smoked by the machine and by three individuals (table 2). The comparison indicates that the smoking machine is a good approximation of actual smoking and can be used to determine the distribution of radionuclides between cigarette smoke and residue.

Table 2. Percentage polonium-210 in cigarette butts, ashes, and filters from smokers versus smoking machine

Type of cigarette	Percent polonium-210	
	Smokers	Smoking machine
Nonfiltered	• 48 ±7	• 47 ±8
Filtered, including filter	50 ±8	53 ±9
Treated, including filter	51 ±8	50 ±8

• Counting error is 2 standard deviations, expressed as percent.

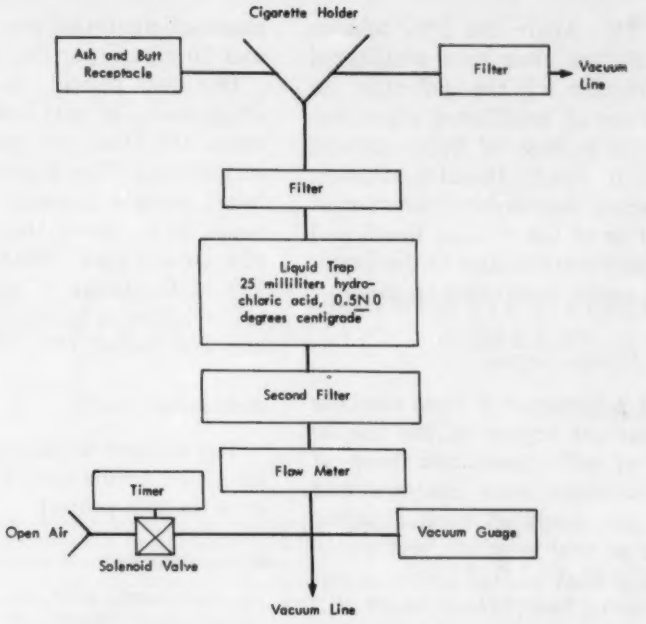

Figure 1. Flow diagram of the smoking machine

Polonium–210 in cigarette smoke and residue

With the smoking machine, material balances for polonium–210 were obtained on four major brands of filtered and nonfiltered cigarettes. The unsmoked cigarette was analyzed for polonium–210. The smoked cigarette was analyzed for polonium–210 in the (a) smoke inhaled, (b) sidestream smoke (smoke not inhaled), (c) unsmoked tobacco and ash, and (d) filter. Each analysis was performed on smoke and residue from one package, or 20 cigarettes. To normalize the data for varying quantities of tobacco in each cigarette, the results are given in picocuries per gram of tobacco (table 3). No attempt was made to determine the polonium–210 expired in the exhaled smoke or reaching the mouth or lungs via the inhaled smoke.

All brands tested showed approximately the same activity per gram in the total cigarette. However, quite diverse activities were evidenced in the inhaled smoke portion. With the exception of a filtered cigarette containing pipe tobacco as a filler, the filtered cigarettes contained 33 to 50 percent less in the inhaled smoke than did nonfiltered cigarettes. The ratio of sidestream to mainstream smoke in the nonfiltered brands appears to be close to unity, whereas the filtered brands demonstrate

Table 3. Polonium-210 material balance, pCi/g tobacco [a]

Sample	Polonium-210 concentration, pCi/g			
	Non-filter	Filter type		
		Cellulose	Cellulose, charcoal, treated	Cellulose, pipe tobacco
Total cigarette	0.411	0.403	0.410	0.357
Inhaled smoke	0.091 (22.2%)	0.061 (15.1%)	0.045 (11.0%)	0.109 (30.7%)
Sidestream smoke	0.100 (24.5%)	0.133 (32.9%)	0.168 (40.8%)	0.116 (32.4%)
Butt and ash	0.191 (46.7%)	0.157 (38.8%)	[b] 0.206 (50.3%)	0.115 (32.2%)
Filter	—	0.055 (13.7%)		0.031 (8.8%)
Material balance, % [c]	93.4±5.4	100.5±5.2	102.1±6.3	104.1±5.2

[a] Numbers in parentheses are percentages of polonium-210 relative to that of original product.
[b] Includes filter.
[c] Total error term is one standard deviation.

ratios of 2.1 to 3.7. Again the pipe tobacco filler exhibits activities close to a nonfiltered cigarette. Distribution of the polonium in the various residues of nonfiltered cigarettes agrees well with the findings of Rajewsky and Stahlhofen (*8*). It would therefore appear that different filtering mechanisms, whether of artificial material or of the tobacco itself, and possibly the cut, are contributing to the variation in activities found in inhaled smoke.

Polonium–210 in human organs

To determine if polonium–210 from smoking concentrates in various organs of the human body, specimens of soft tissue and bone of smokers and nonsmokers were analyzed and compared (table 4). Samples were obtained through autopsies at local hospitals, and smoking histories were available. Soft tissue chosen for the study were lung, liver, kidney, heart, and psoas muscle. Blood drained from the heart was used for fluid tissue, and spine for the skeletal tissue. The age of the smokers ranged from 36 to 80 years; of nonsmokers from 47 to 76. Smokers, as referred to in table 4, were composed of those people smoking one to three packs of cigarettes per day for 22 to 40 years, and 10 cigars per day for 10 years.

Table 4. Polonium-210 in human organs

Tissue	Concentration, pCi/100 g wet tissue		
	Smoker	Nonsmoker	Smoker/ nonsmoker
Lung	[a] 0.65±.12 [b] (14)	0.31±.05 (7)	2.10±.51
Liver	1.25±.25 (12)	1.03±.18 (10)	1.21±.32
Kidney	0.79±.15 (12)	0.80±.19 (10)	0.99±.30
Muscle (psoas)	0.08±.025 (4)	0.08±.025 (4)	1.00±.45
Blood	0.19±.07 (6)	0.13±.04 (5)	1.46±.63
Bone (spine)	3.16±.76 (6)	3.05±.38 (6)	1.04±.28
Heart	0.24±.07 (12)	0.26±.07 (10)	0.92±.36

[a] Figures in parentheses are number of samples analyzed.
[b] Total error term is one standard deviation.

Our tests indicate the lung, blood, and liver of smokers, in that order, contain more polonium–210 than the corresponding organs of nonsmokers. The polonium–210 in the kidney, heart, muscle (psoas), and bone (spine), appears to be about the same level in smokers and nonsmokers. Measured activities and ratios of the lungs of smokers and nonsmokers are comparable to values obtained by Rajewsky and Stahlhofen (*8*).

Acknowledgment

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MAINE'S EXPERIENCE WITH A STATE-OPERATED PERSONNEL MONITORING PROGRAM FOR RADIATION WORKERS

J. W. Fuller[1]

In a 10-year program of monitoring exposures of radiation workers, Maine's Department of Health and Welfare found increasing acceptance of its free film badge services. Results of findings are outlined. Review of film badge exposure records during examination of over 5,000 film badges in 1965 indicated that exposure of the great majority of individuals was relatively low. Periodic radiological health surveys of installations using independent film badge services indicated that no exposures to individual workers exceeded 100 milliroentgens per week.

Maine's Department of Health and Welfare has operated a statewide film badge program for personnel monitoring of radiation workers since 1956. Although the State of Illinois in recent years has had a central file on radiation exposures among radiation workers, and some States have provided film badges on a limited scale during certain phases of their radiological health programs, Maine is the only State, so far as is known, that provides the film badges as well as a central file of the exposure findings on a continuing basis.[2]

Maine, whose current population is approximately one million, initiated this program for the following reasons:

1. Only one hospital and one industrial firm utilized personnel monitoring for radiation workers in 1954.

2. Preliminary surveys had revealed several examples of inadequate shielding and poor operating procedures among radiation users in the State.

3. Some dentists and veterinarians showed evidence of radiation injuries. It was felt that many other radiation personnel may have been overexposed to radiation as well, although signs of injury were not overt.

4. It was believed that a film badge service would provide a record of radiation exposures which would be useful in workmen's compensation cases where claims of radiation injury might be contested.

5. It was believed that a film badge service would develop an awareness of the potential hazards of radiation, would promote interest in radiation protection for both X-ray personnel and patients, and would make the introduction of State rules and regulations pertaining to radiation a much easier step.

As the availability of this service became known, the use of the State's film badges by various radiation installations in Maine gradually increased from a total of 2,280 film badges

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per year in 1956 to 5,086 in 1965. During fiscal year 1965, 580 individuals, representing about 75 percent of the workers in Maine occupationally exposed to ionizing radiation (other than dentists, dental assistants, and dental hygienists), took advantage of the State's film badge program. Of these 580 people, 100 were part-time users and 409 were full-time users who wore the badges either for 2- or 4-week periods, depending on their workload, and 171 were doctors or dentists who wore the film badges for short periods to evaluate the radiation hazard in their offices.

In recent months, the system has included 405 physicians (M.D.'s and osteopaths), X-ray technicians and nurses employed in radiation work in hospitals; 16 dentists, dental assistants, and dental hygienists; 18 physicians and technicians using X-ray equipment in clinics and offices; a few other X-ray workers; and 141 isotope users. About 24 percent of the workers monitored in the program use radioactive materials licensed by the U.S. Atomic Energy Commission.

Stainless-steel film badge holders were purchased initially for use for this program. They were soon found to be unsuitable by nurses and female X-ray technicians because of their weight and bulk. Plastic film badge holders were subsequently purchased and used in the non-industrial radiation settings. However, the stainless-steel film badge holders are still used by the workers in industrial radiation installations. Each batch of 2,000 films purchased three times a year is calibrated by using an NBS certified radium needle for gamma radiation, a slug of natural uranium for beta radiation, and an X-ray machine with 2.5 mm of aluminum operated at 75 kVp for X-ray, as the majority of our film badge users are operating their equipment in the 75 kVp range.

Ordinarily the film badges are worn for periods of 2 weeks by groups with heavy workloads, and monthly by all others. The State pays postage for the film badges sent to the users and the users pay postage for the exposed film badges returned to the State. When the film badges have been processed, the Department of Health and Welfare institutes a follow-up of any unusual exposure.

A copy of the report is returned to the users; however, the original report of the badge reading and the film badge itself are maintained in permanent files in the Department of Health and Welfare. It was observed that beyond a 3-year period, the image on these film badges had begun to fade; and after 5 years, the image had faded so badly that the value of the film as a record is very questionable. Table 1 gives the average occupational radiation exposures for each year calculated for the monitored radiation personnel, assuming that all such persons have worn their badges 6 months or more each year of the exposure period.

Table 1. Average film badge reading per person

Year	Number of users	Average reading [a] (mR/month)
1956–1957	131	18
1957–1958	145	35
1958–1959	158	19
1959–1960	167	50
1960–1961	200	33
1961–1962	230	9
1962–1963	241	10
1963–1964	258	21
1964–1965	306	20

[a] Sensitivity is approximately 1 mR.

It should be taken into consideration that the workload of most hospitals has increased in the last few years; therefore, the reduction in exposure rate received was not as clearly shown by table 1 as if the workload had been constant. Where individual hospitals replaced their old buildings and installed properly shielded X-ray equipment, the reduction was greater.

Somewhat higher exposures have occurred among X-ray personnel employed in some of the large, old hospitals in the State. It is felt that these slightly higher exposures are due to the relatively heavy X-ray workloads that have been imposed on obsolescent equipment and facilities, and that the situation will be improved as modern hospitals are built to replace the old ones. Generally smaller radiation exposures have been found among dentists, dental assistants, and dental hygienists; industrial radiographers doing cabinet radiography; hospital and research laboratory workers using AEC-licensed nuclides; and X-ray personnel employed in small hospitals where the X-ray workload has been light.

Under the State-operated program, 5,086 badges were processed during fiscal year 1965, 34 of which gave indications of greater than 100 mR/week, the short-term limit on radiation exposure used for program purposes. No individual, however, had an indicated exposure in excess of 5 R for the year. Table 2 shows the distribution of badge readings. Followup of the indicated overexposure cases usually revealed that good practices had been breached, such as a technician holding a subject during radiography. In some cases, there were reasons to believe the film badge had been carelessly exposed by leaving it, improperly, near a radiation source.

Table 2. Distribution of badge readings for fiscal year 1965

mR/week	Number of film badges
<2	3,127
2– 24	1,688
25– 49	161
50– 74	41
75– 99	24
100–199	23
200–299	16
300–399	1
400–499	2
500–599	2
>2,000	1
Total	5,086

A relatively small number of radiation installations in Maine utilize film badge services other than the service available from the State. These installations are not required to report the film badge findings. However, each user must maintain records of the findings of his film badge program, and these records are reviewed by State personnel during periodic radiological health surveys. No instance of exposures of more than 100 mR/week to ionizing radiation has come to light through this record system.

There are many individual users of X-ray equipment in Maine who are not monitored on a regular basis for radiation exposures. These include about 610 dentists and dental technicians, about 325 individuals (physicians, technicians, and others), such as those working in 25 small hospitals and private medical offices where X-rays are used only occasionally, and 82 persons who work around thickness gauges in which AEC-controlled nuclides are used. Over the 10-year period, 69 dentists and 107 dental technicians have worn our film badges. Of these, only seven dentists and 16 dental technicians wore the badges for more than 2-year periods. The majority were worn for only about 6 months; and in all cases the dose received per week was from less than 2 mR to 15 mR, with an average of 3 mR per week for all badges worn. Periodically a determination has been made by radiation inspectors from the Department of Health and Welfare that the radiation level in the positions occupied by these radiation workers during their employment is less than 25 percent of the permissible dose to individuals in a controlled area[3] and continuous personnel monitoring is not considered to be essential. Should the mode of operation of the radiation installations change, however, film badges are available on request to determine whether the levels of radiation exposure are sufficiently increased to warrant a regular monitoring program. Many of the 25 smaller hospitals will reinstitute personnel monitoring among radiation workers as one of the conditions of participation for hospitals under the Medicare Program. Personnel monitoring is not required if there is adequate evidence that the exposures will not exceed 25 percent of the permissible dose to individuals in a controlled area.[3]

There are about 77 radiation installations in Maine using the State's badge program. These installations include 49 hospitals, 8 dental offices, 9 medical clinics and physicians' offices, 2 veterinarians, 2 industries, 2 colleges, and 1 large research laboratory, as well as 4 State agencies.

There are about 248 radiation workers in Maine, including approximately 25 students in a one-semester course in a college, who use materials controlled by the Atomic Energy Commission. Of these, about 141 (56 percent) are monitored for radiation exposures on a regular basis through the State's film badge program.

By way of comparison, there are about 1,350 radiation workers using radium and the types of X-ray equipment used in industry, educational institutions, and the practice of medicine, dentistry, and other forms of the healing arts.

[3] "State of Maine Rules and Regulations Relating to Protection," Section B–10, page 23, indicates a permissible level of 100 mR/week.

Approximately 440 (32 percent) are monitored by the State's program.

The radiation exposures associated with medical and dental examinations, when radiation workers are patients under the care of a practitioner of the healing arts, are not assessed under this program.

Prior to the institution of this program in 1956, there had been several instances of radiation injuries among dentists and veterinarians in particular, such as severe radiation injuries of the fingers. Since 1956 there has been no known instance of occupationally related radiation injury among the radiation workers in the State of Maine. This improvement is thought to be due in part to the increased awareness of the hazards of ionizing radiation brought about by the State's personnel monitoring program.

The followup program dealing with suspiciously high readings on the film badges has uncovered a few instances of poor radiation practice. One advantage of the approach used in Maine is that the Department of Health and Welfare, through its operation of the film badge program, is alerted to possible overexposures relatively soon after they occur. This permits prompt followup and facilitates a reconstruction of the circumstances that lead to higher-than-usual badge reading.

Averaged out for the population of the State of Maine, the contribution to the genetic pool from occupational exposure among its radiation workers amounts to somewhat less than 1 mR/year. This is to be compared against radiation exposures amounting to about 100 mR/year from natural background and exposures perhaps in the range of from 50 to 100 mR, due to irradiation of members of the population incidental to the practices of the healing arts in the State.

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide, however, an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission of Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

1. Pasteurized Milk Network May 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

The results for May 1966 and for the first quarter of 1966 are presented in table 1. The

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average radionuclide concentration in pasteurized milk for the first quarter and May 1966 [a]

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966	First quarter 1966	May 1966
Ala:	Montgomery	<5	<5	12	12	25	30	0	20	0	0
Alaska:	Palmer	<5	<5	14	15	40	45	0	20	0	0
Ariz:	Phoenix	<5	<5	4	2	15	10	0	0	0	0
Ark:	Little Rock	<5	25	26	38	40	50	0	80	0	20
Calif:	Sacramento	<5	<5	6	7	15	15	0	0	0	0
	San Francisco	<5	<5	7	8	20	20	0	0	0	0
C.Z:	Cristobal	<5	<5	4	4	25	20	0	0	0	0
Colo:	Denver	<5	<5	11	11	25	25	0	0	0	0
Conn:	Hartford	<5	<5	11	11	40	40	0	0	0	0
Del:	Wilmington	<5	<5	13	17	40	40	0	10	0	0
D.C:	Washington	<5	<5	12	14	30	30	0	0	0	0
Fla:	Tampa	<5	<5	11	11	105	115	0	10	0	0
Ga:	Atlanta	<5	5	19	21	45	45	0	20	0	0
Hawaii:	Honolulu	<5	<5	5	7	35	30	0	0	0	0
Idaho:	Idaho Falls	<5	<5	13	15	45	40	0	0	0	0
Ill:	Chicago	<5	<5	11	14	35	35	0	0	0	0
Ind:	Indianapolis	<5	10	12	13	30	30	0	50	0	10
Iowa:	Des Moines	<5	<5	14	17	30	30	0	20	0	0
Kans:	Wichita	<5	<5	13	15	20	25	0	30	0	0
Ky:	Louisville	<5	10	16	21	25	25	0	20	0	0
La:	New Orleans	<5	<5	29	31	40	45	0	10	0	0
Maine:	Portland	<5	<5	15	16	65	70	0	0	0	0
Md:	Baltimore	<5	<5	13	16	30	30	0	0	0	0
Mass:	Boston	<5	10	14	15	60	65	0	0	0	0
Mich:	Detroit	<5	<5	11	12	35	35	0	10	0	0
	Grand Rapids	<5	<5	14	15	45	50	0	0	0	0
Minn:	Minneapolis	<5	<5	20	24	40	45	0	10	0	0
Miss:	Jackson	<5	5	23	29	25	35	0	10	0	0
Mo:	Kansas City	<5	15	15	18	20	25	0	50	0	0
	St. Louis	<5	35	15	20	30	30	0	60	0	0
Mont:	Helena	<5	<5	15	15	55	55	0	0	0	0
Nebr:	Omaha	<5	<5	15	17	25	30	0	10	0	0
Nev:	Las Vegas	<5	<5	7	5	20	25	0	10	0	0
N.H:	Manchester	<5	10	18	15	75	70	0	0	0	0
N.J:	Trenton	<5	<5	12	11	40	30	0	0	0	0
N. Mex:	Albuquerque	<5	<5	6	6	15	15	0	0	0	0
N.Y:	Buffalo	<5	<5	10	11	40	45	0	0	0	0
	New York	<5	<5	13	15	45	45	0	0	0	0
	Syracuse	<5	<5	10	12	40	45	0	0	0	0
N.C:	Charlotte	<5	<5	20	21	30	35	0	30	0	0
N. Dak:	Minot	<5	<5	31	38	45	45	0	5	0	0
Ohio:	Cincinnati	<5	5	12	16	25	30	0	10	0	0
	Cleveland	<5	<5	13	14	35	40	0	0	0	0
Okla:	Oklahoma City	<5	10	13	15	25	25	0	40	0	10
Ore:	Portland	<5	<5	12	13	35	40	0	0	0	0
Pa:	Philadelphia	<5	<5	12	14	35	35	0	0	0	0
	Pittsburgh	<5	<5	17	20	45	50	0	0	0	0
P.R:	San Juan	<5	<5	8	8	25	25	0	20	0	0
R.I:	Providence	<5	10	12	12	45	45	0	0	0	0
S. C:	Charleston	<5	5	23	22	45	50	0	30	0	0
S. Dak:	Rapid City	<5	<5	19	26	45	50	0	0	0	0
Tenn:	Chattanooga	<5	<5	21	21	25	30	0	20	0	0
	Memphis	<5	5	17	20	15	20	0	30	0	0
Tex:	Austin	<5	<5	6	6	15	20	0	10	0	0
	Dallas	<5	10	14	18	20	30	0	30	0	0
Utah:	Salt Lake City	<5	<5	13	13	40	35	0	0	0	0
Vt:	Burlington	<5	<5	14	13	55	55	0	0	0	0
Va:	Norfolk	<5	<5	16	17	25	25	0	0	0	0
Wash:	Seattle	<5	<5	15	19	40	55	0	0	0	0
	Spokane	<5	<5	15	20	40	40	0	0	0	0
W. Va:	Charleston	<5	<5	14	18	25	20	0	10	0	0
Wis:	Milwaukee	<5	5	11	9	40	45	0	0	0	0
Wyo:	Laramie	<5	<5	14	14	30	35	0	0	0	0
Network average		<5	<5	13.8	15.6	35	38	0	11	0	1

[a] Calcium analyses were discontinued as of March 31, 1966.

average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value, except for iodine–131 and barium–140, where zero was used for averaging purposes.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations May 1965 and December 1965–May 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965		1966				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 10	4	9	10	9	9	8	10
10–19	26	43	46	46	44	50	38
20–29	25	11	6	7	7	3	12
30–39	5	0	1	1	3	2	3
40–49	2	0	0	0	0	0	0
50–59	0	0	0	0	0	0	0
60–69	1	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, May 1965 and December 1965–May 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965		1966				
	May	Dec	Jan	Feb	Mar	Apr	May
Under 50	17	51	57	56	56	55	51
50–99	31	11	5	6	6	7	11
100–149	13	1	1	1	1	1	1
150–199	2	0	0	0	0	0	0

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for May 1965 and for December 1965 through May 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

In anticipation of a significant increase in iodine–131 levels in pasteurized milk, as a result of atmospheric nuclear detonations (*2*), the sampling and analysis frequency for this radionuclide was increased to twice weekly as of May 16. The individual sample results for the second half of May are presented in table 4.

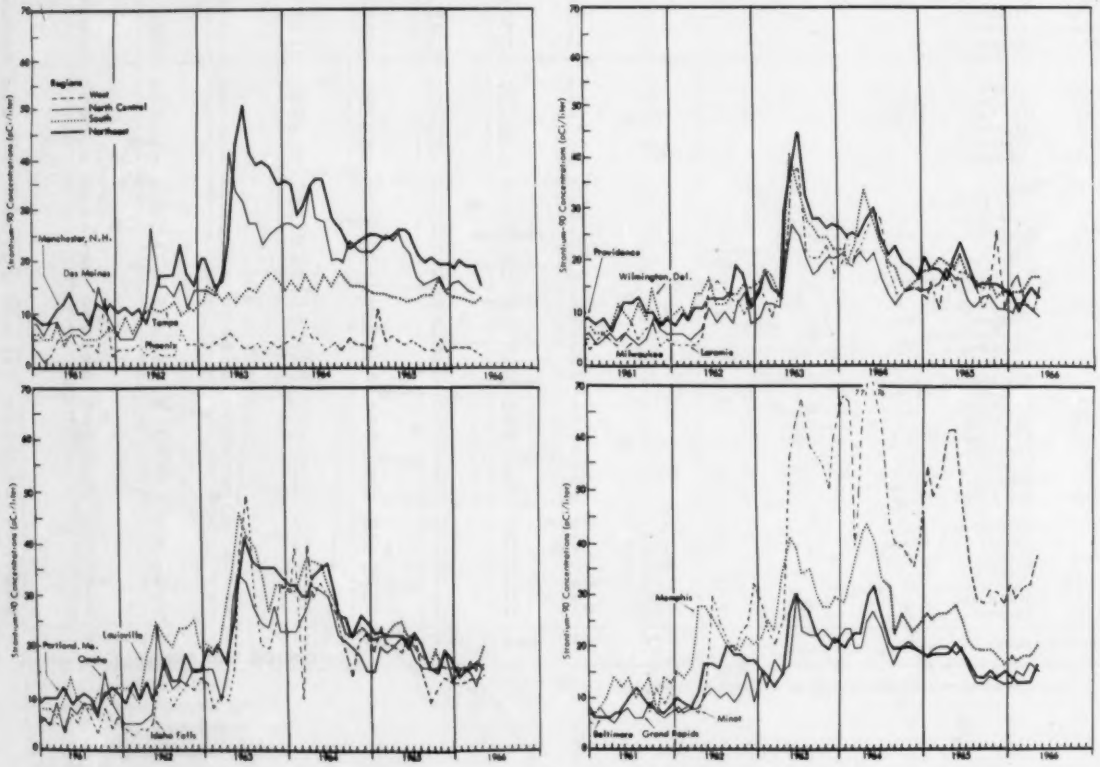

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961—May 1966

Table 4. Daily iodine-131 concentrations in pasteurized milk, May 17–31, 1966

Sampling locations		Daily iodine-131 concentrations, pCi/liter													
		May 1966													
		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Ala:	Montgomery	<10		<10				50			38					
Alaska:	Palmer	<10			<10				80			<10				
Ariz:	Phoenix	<10			<10				<10			30				
Ark:	Little Rock								392			196				
Calif:	Sacramento	<10			<10				<10			<10				
	San Francisco	<10		<10					<10			<10				
C.Z:	Cristobal							<10								
Colo:	Denver	<10		<10					<10			<10				
Conn:	Hartford	<10			<10				11			<10				
Del:	Wilmington	<10			29							14				
D.C:	Washington	<10		<10					20		17					
Fla:	Tampa	<10			31				31			14				
Ga:	Atlanta	<10		15					36			31				
Hawaii:	Honolulu			<10					<10			<10				
Idaho:	Idaho Falls	<10			<10				<10			<10				
Ill:	Chicago	<10		<10					29		22					
Ind:	Indianapolis	<10			75			132				188				
Iowa:	Des Moines	<10			<10				50			60				
Kans:	Wichita	<10		<10					110			80				
Ky:	Louisville	<10	29						35			39				
La:	New Orleans	<10			<10					34		22				
Maine:	Portland			<10				17			14					
Md:	Baltimore	<10			<10				26			15				
Mass:	Boston	<10			<10				<10			12				
Mich:	Detroit	<10			17				29			35				
	Grand Rapids				<10				16			27				
Minn:	Minneapolis	<10			<10				30			30				
Miss:	Jackson				<10				27			43				
Mo:	Kansas City	<10			80				145			120				
	St. Louis			<10				280			170		180			
Mont:	Helena	<10			<10				<10			<10				
Nebr:	Omaha	<10			<10				<10			60				
Nev:	Las Vegas		<10		<10				<10			20				
N.H:	Manchester	<10		<10					15			<10				
N.J:	Trenton	<10			<10				<10			<10				
N. Mex:	Albuquerque			<10				<10			10					
N.Y:	Buffalo								10			<10				
	New York			<10				<10			<10					
	Syracuse	<10			<10				22			<10				
N.C:	Charlotte			26				65				64				
N. Dak:	Minot			<10				<10			10					
Ohio:	Cincinnati	<10			<10				71			52				
	Cleveland	<10			<10				37			45				
Okla:	Oklahoma City				12				137			118				
Ore:	Portland	<10			<10			<10				10				
Pa:	Philadelphia	<10			<10				15			25				
	Pittsburgh	<10			<10				20			17				
P.R:	San Juan								18			25				
R.I:	Providence	<10			<10				<10			21				
S.C:	Charleston	<10			13				52			103				
S. Dak:	Rapid City	<10			<10				10			30				
Tenn:	Chattanooga	<10			<10				44			37				
	Memphis	<10		13				106			96					
Tex:	Austin				<10				20			48				
	Dallas				13			49			100					
Utah:	Salt Lake City								<10							
Vt:	Burlington	<10		<10					<10			<10				
Va:	Norfolk	<10			<10				18			21				
Wash:	Seattle	<10			<10				<10			20				
	Sookane	<10			<10											
W. Va:	Charleston				<10				33			25				
Wis:	Milwaukee	<10			<10				<10			17				
Wyo:	Laramie	<10			<10				<10			20				

2. Canadian Milk Network[1] May 1966

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. The locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*3*).

The May 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5.

During this period, strontium–89 and iodine–131 concentrations were below detectable levels.

[1] Prepared from June 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, May 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.5	21.2	71
Edmonton	1.10	1.5	19.2	57
Ft. William	1.13	1.6	29.9	90
Fredericton	1.08	1.6	27.0	71
Halifax	1.16	1.6	22.5	89
Montreal	1.13	1.5	17.0	57
Ottawa	1.17	1.5	12.8	50
Quebec	1.12	1.6	26.9	93
Regina	1.08	1.4	20.0	47
St. John's Nfld	1.13	1.5	22.8	93
Saskatoon	1.13	1.5	19.9	40
Sault Ste. Marie	1.10	1.6	23.2	82
Toronto	1.17	1.5	9.1	45
Vancouver	1.17	1.5	30.4	106
Windsor	1.19	1.6	12.0	62
Winnipeg	1.05	1.6	16.9	61
Average	1.13	1.5	20.7	70

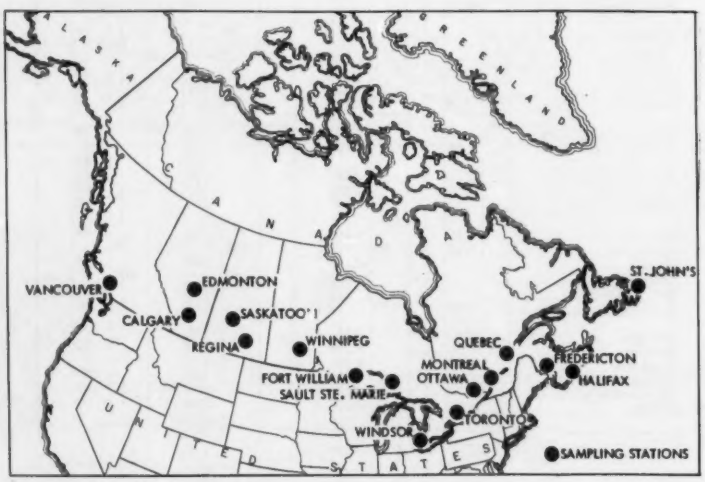

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program May 1966

Pan American Health Organization and
U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*4*).

Table 6 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly concentrations for May 1966.

Additional data

Data from Caracas, Venezuela, for March and April 1966 was not previously reported in the July and August 1966 issues of *Radiological Health Data and Reports* and have been added to table 6.

Figure 4. Pan American Milk Network sampling stations

Table 6. Stable element and radionuclide concentrations in PAHO milk, May 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Canal Zone:							
Cristobal	NA	1.5	<5	4	<10	20	<10
Jamaica:							
Kingston	NS	NS	NS	NS	NS	NS	NS
Mandeville	1.09	1.29	20	9	180	140	50
Montego Bay	NS	NS	NS	NS	NS	NS	NS
Puerto Rico:							
San Juan	NA	1.5	<5	8	20	25	<10
Venezuela:							
Caracas							
(March 1966) [a]	1.10	1.44	<5	3	<10	10	<10
(April 1966) [a]	1.10	1.49	<5	4	<10	<10	<10
(May 1966) [a]	1.10	1.60	<5	5	20	30	<10

[a] Data for March and April 1966 not reported in the July and August issues of Radiological Health Data and Reports.
NA, no analysis.
NS, no samples collected.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).
(*2*) PUBLIC HEALTH SERVICE. Reported nuclear detonations, May 1966. Rad Health Data Rep 7:376 (June 1966).
(*3*) CANADIAN DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).
(*4*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance programs are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

Milk network	Period reported	Last presented
Colorado	October–December 1964	April 1965
Connecticut	January–March 1966	August 1966
Florida	January–March 1966	July 1966
Indiana	January–March 1966	August 1966
Michigan	October–December and annual summary 1965	May 1966
Minnesota	January–March 1966	August 1966
New York	July–December and annual summary 1965	May 1966
Oklahoma	January–March 1966	July 1966
Pennsylvania	January–March 1966	August 1966
Texas	January–March 1966	July 1966

1. California Milk Network January–March 1966

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk-monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture as representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium-90 concentrations are determined radiochemically.

Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period January to March 1966.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2.

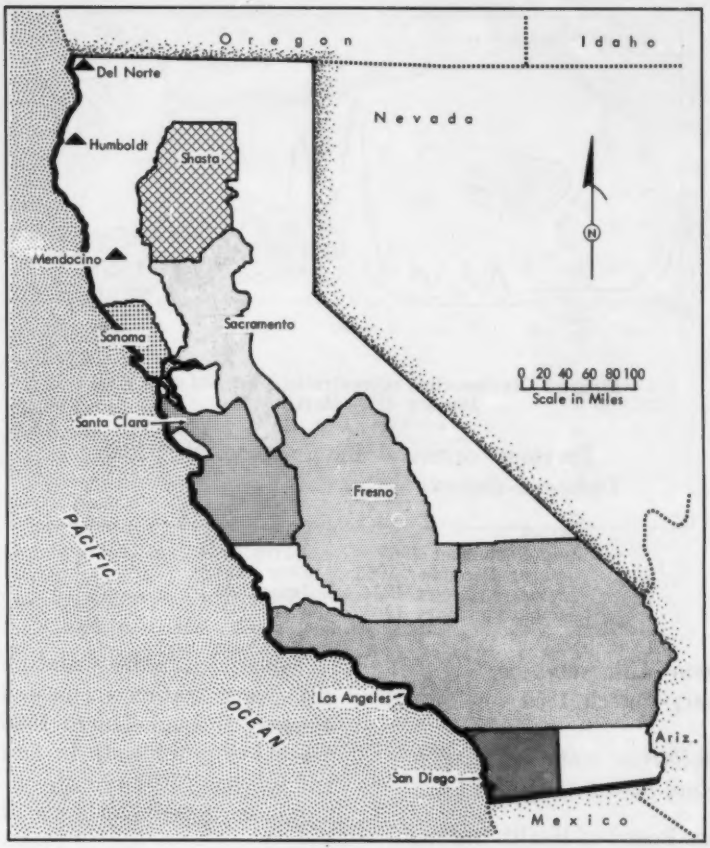

Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, January–March 1966

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium, g/liter											
January	1.39	1.23	1.24	1.09	1.27	1.27	1.14	1.06	1.21	1.24	1.21
February	1.29	1.24	1.18	1.14	1.18	1.22	1.14	1.23	1.20	1.22	1.20
March	1.26	1.20	1.24	1.11	1.16	1.21	1.00	1.19	1.15	1.26	1.18
Potassium-40, pCi/liter											
January	1,110	1,270	1,260	1,240	1,280	1,210	1,400	1,170	1,270	1,270	1,250
February	1,090	1,190	1,190	1,160	1,250	1,200	1,170	1,270	1,200	1,190	1,190
March	1,170	1,250	1,200	1,210	1,210	1,270	1,190	1,360	1,210	1,250	1,230
Strontium-89, pCi/liter											
January	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
February	*3.5	ND	0.9	ND	ND	ND	ND	ND	ND	ND	0.4
March	ND	ND	0.2	0.3	4.0	0.3	ND	ND	ND	0.2	0.5
Strontium-90, pCi/liter											
January	27	5.0	9.2	3.5	7.0	5.0	4.0	3.0	8.0	6.3	7.8
February	21	4.0	7.0	5.0	5.0	5.0	3.0	3.0	7.0	5.3	6.5
March	23	3.4	12.0	3.4	9.0	5.0	3.0	4.0	9.0	7.0	7.9
Cesium-137, pCi/liter											
January	64	21	18	11	18	22	*13	9	23	19	22
February	41	26	21	24	18	22	10	21	32	21	23
March	51	13	31	8	26	31	*6	29	76	30	30

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.
ND, below detectable limits.

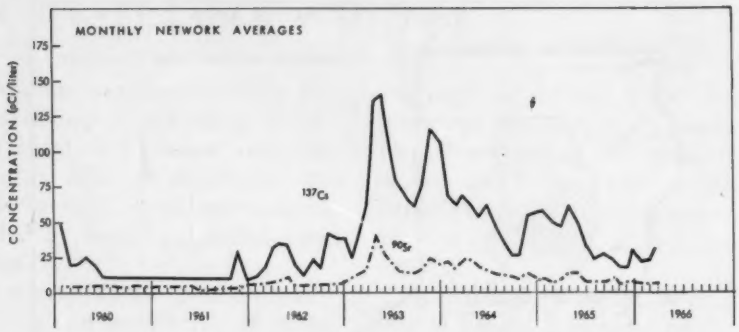

Figure 2. Radionuclide concentrations in California milk January 1960—March 1966

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–September 1963	March 1964
October–December 1963	June 1964
Annual summary 1964	June 1966
Annual summary 1965	June 1966

2. Oregon Milk Network January–March 1966

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program, routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentration in pasteurized milk from January through March 1966. These data are presented graphically in figure 4. Iodine–131 and barium–140 concentrations remained below minimum detectable levels of 15 pCi/liter.

Table 2. Radionuclide concentrations in Oregon milk, January–March 1966

Sampling location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		Jan	Feb	Mar	Jan	Feb	Mar
Baker	M	10	NA	NA	25	20	30
Coos Bay	M	15	NA	NA	50	50	45
Eugene	M	10	NA	NA	30	25	40
Medford	M	10	NA	NA	25	30	40
Nyssa	M	10	NA	NA	25	35	30
Portland composite	W	15	10	13	40	35	35
Portland local	W	15	NA	NA	45	35	45
Redmond	M	10	NA	NA	50	35	30
Tillamook	M	25	NA	NA	65	60	60
Average	—	15	10	13	40	35	39

M, sampled monthly.
W, sampled weekly.
NA, no analysis.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Summary 1962–1964	June 1965
Annual summary 1965	June 1966

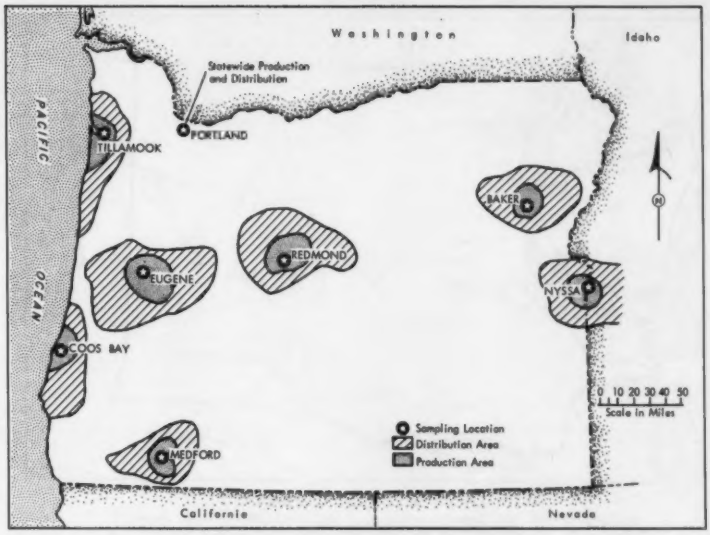

Figure 3. Oregon milk production and distribution areas

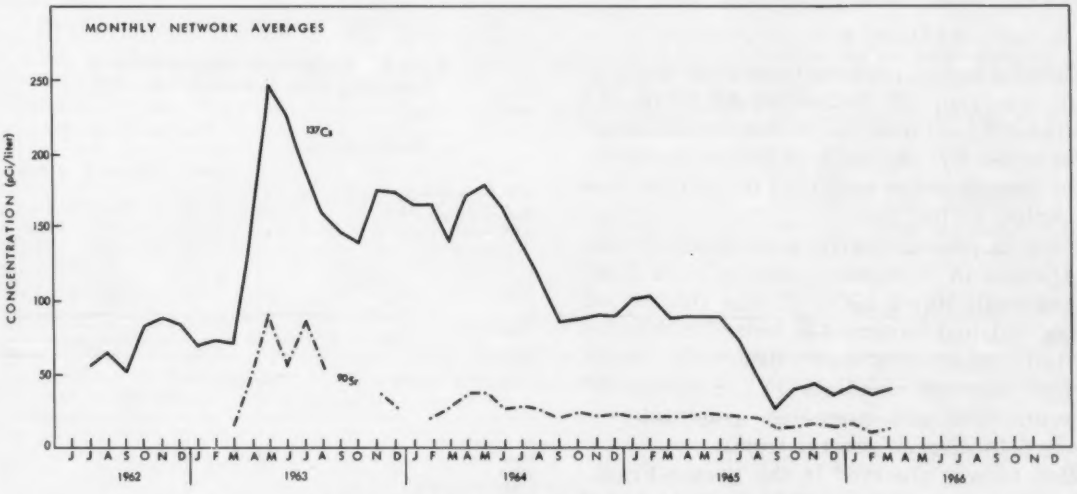

Figure 4. Radionuclide concentrations in Oregon milk network, June 1962—March 1966

3. Washington Milk Network January–March 1966

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The State of Washington Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

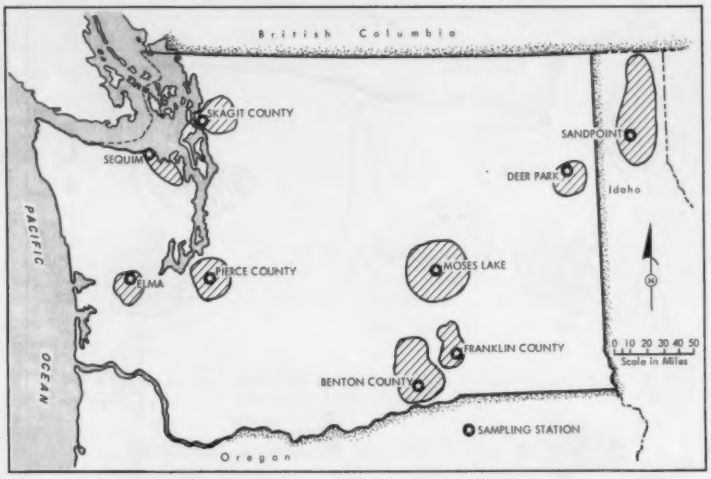

Figure 5. Washington milksheds and sampling locations

Selected samples are analyzed radiochemically for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for January through March 1966. During this period, iodine–131 and barium–140 concentrations remained below minimum detectable levels. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to display general trends.

Zinc–65 was observed in the Benton-Franklin area on three occasions during this period (table 4). This nuclide has periodically appeared in these areas as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
December 1962–December 1963	May 1964
Summary 1964 and 1965	June 1966

Table 3. Radionuclide concentrations in Washington milk, January–March 1966

Sampling location	Potassium-40, pCi/liter		
	January	February	March
Benton County	1,370	1,150	NS
Deer Park	1,240	1,200	1,240
Elma	1,360	1,280	1,290
Franklin County	NS	NS	1,170
Moses Lake	1,270	1,310	1,160
Pierce County	1,270	1,260	1,200
Sandpoint	1,330	1,260	1,090
Sequim	1,360	1,270	1,300
Skagit County	1,270	1,190	1,300
Average	1,309	1,240	1,083
	Strontium-90, pCi/liter		
Benton County	7	7	NS
Deer Park	12	17	11
Elma	9	16	17
Franklin County	NS	NS	5
Moses Lake	7	9	6
Pierce County	10	14	11
Sandpoint	29	37	32
Sequim	14	11	11
Skagit County	8	15	7
Average	12	16	13
	Cesium-137, pCi/liter		
Benton County	23	20	NS
Deer Park	32	39	38
Elma	28	98	40
Franklin County	NS	NS	34
Moses Lake	25	30	26
Pierce County	43	40	42
Sandpoint	85	90	80
Sequim	40	42	51
Skagit County	30	42	25
Average	38	50	42

NS, no sample collected.

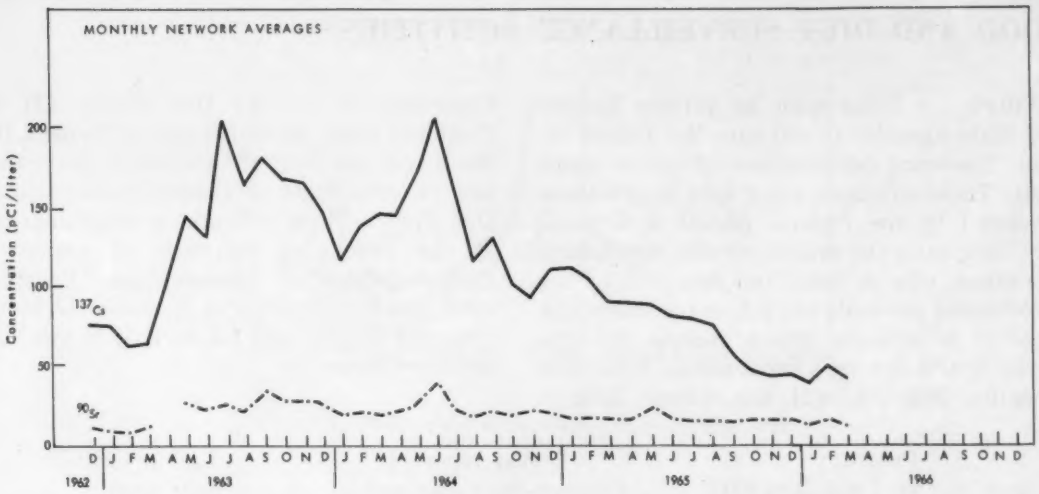

Figure 6. Radionuclide concentrations in Washington milk, 1962—March 1966

Table 4. Milk samples in Washington State containing zinc-65

Sampling location	Collection date, 1966	Zinc-65 (pCi/liter)
Benton County	January 7	104
Benton County	February 7	40
Franklin County	March 7	44

REFERENCES

(*1*) HESLEP, J. M., and A. C. CORNISH. California milk network and milkshed comparisons, April-June 1963. Rad Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960-June 1962. Rad Health Data 4:90–92 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Rad Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January-June 1965. Rad Health Data: 6:619–621 (November 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically herein include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
Institutional Total Diet PHS	October–December and annual summary 1965	July 1966
Teenage Diet, FDA	February–November 1965	August 1966
Connecticut Standard Diet	January–June 1965	February 1966

1. Strontium–90 in Tri-City Diets November 1965–January 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities every 3 months on a staggered basis (i.e., New York City, November 1965; San Francisco, December 1965; Chicago, January 1966) and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately five percent. Therefore, this figure is used to calculate their contribution to the total strontium–90 dietary intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for

[1] Data from Fallout Program Quarterly Summary Report, HASL 172. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

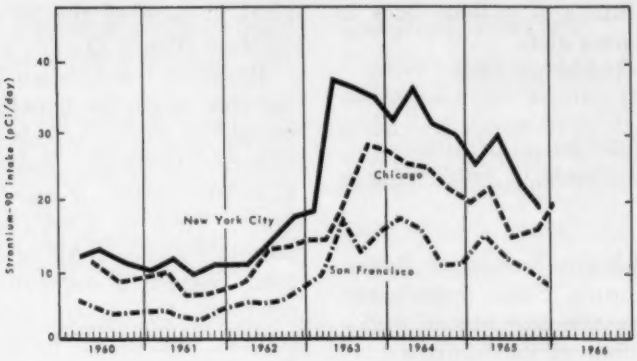

Figure 1. Daily intake of strontium-90 in Tri-City diet 1960—January 1966

the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been previously summarized (*3*).

Results of the November 1965 to January 1966 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1. A discussion of cesium-137 intakes as reflected in the Tri-City Diet Study is presented elsewhere (*4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Sixteenth sampling (February–April 1964)	December 1964
Seventeenth sampling (July–September 1964)	March 1965
Eighteenth sampling (August–October 1964)	June 1965
Nineteenth sampling (November 1964–January 1965)	September 1965
Twentieth sampling (February–April 1965)	December 1965
Twenty-first sampling (May–July 1965)	March 1966
Twenty-second sampling (August–October 1965)	June 1966

Table 1. Average dietary consumption and strontium-90 intake in Tri-City Diet, November 1965–January 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City November 1965		San Francisco December 1965		Chicago January 1966	
			pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Bakery products	37	37.0	13.4±0.9	496	9.0±0.9	333	14.6±1.0	540
Whole grain products	11	10.0	33.4±1.5	367	20.5±1.3	225	26.4±1.4	290
Fresh vegetables	43	15.0	22.4±0.6	963	4.4±0.4	189	8.9±0.4	383
Root vegetables	17	6.1	11.1±0.4	189	14.8±0.5	252	10.5±0.4	178
Milk	221	234.4	17.6±0.2	3,890	4.5±0.3	994	16.5±0.4	3,646
Flour	43	8.6	13.2±0.4	568	3.7±0.2	159	18.3±0.4	787
Macaroni	3	0.7	9.4±0.4	28	11.4±0.5	34	12.0±0.5	36
Rice	3	1.1	2.6±0.2	8	3.4±0.3	10	4.4±0.3	13
Dried beans	3	2.9	8.0±2.0	24	28.1±1.7	84	16.7±1.4	50
Fresh fruit	68	12.6	7.3±3.0	496	3.1±0.3	211	3.4±0.6	231
Potatoes	45	5.8	8.8±0.5	396	3.1±0.5	140	7.3±0.5	328
Canned fruit	26	1.3	7.8±0.2	203	2.3±0.1	60	2.2±0.1	57
Fruit juices	19	1.7	5.2±0.2	99	4.5±0.3	86	3.8±0.3	72
Canned vegetables	20	4.2	14.1±0.5	282	4.8±0.4	96	14.3±0.6	286
Meat, fish, poultry, shellfish, and eggs	99	42.0	----------	[a] 422	----------	[a] 151	----------	[a] 363
Annual intake, pCi/yr	----------	383	----------	8,431	----------	3,024	----------	7,260
Daily intake, pCi/day	----------	1.05	----------	23.0	----------	8.3	----------	19.9
Strontium-90/calcium, pCi/g	----------	----------	----------	22.0	----------	7.9	----------	19.0

[a] Estimated as 5 percent of total intake.

2. Estimated daily intake of radionuclides in California diets September–December 1965

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*5*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals, operating with trained dieticians, exist in each of the 20 selected areas. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample

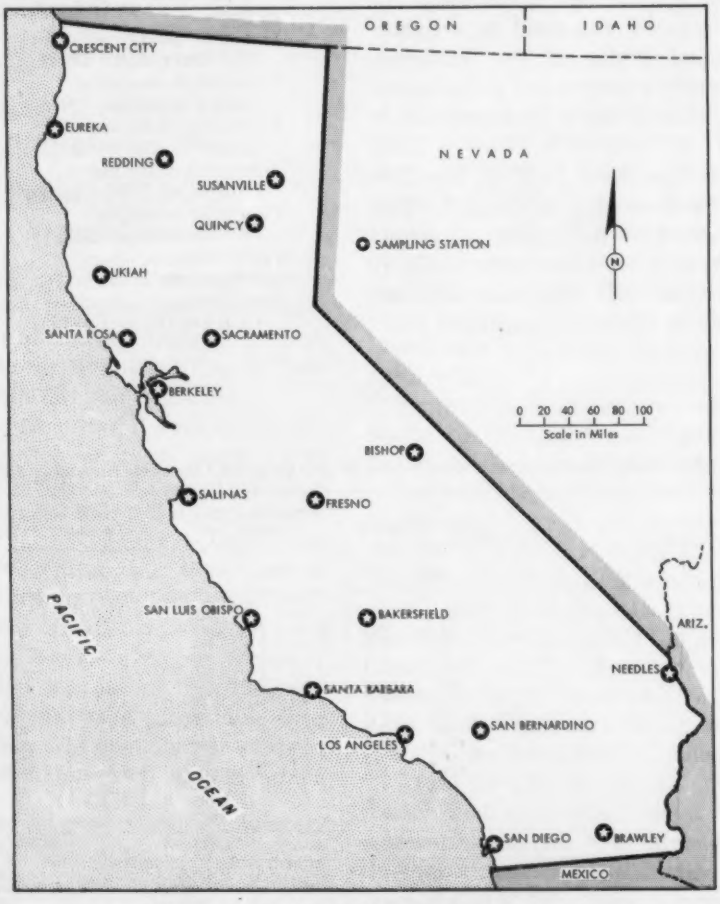

Figure 2. California diet sampling stations

represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized and gamma scanned, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, potassium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of

Table 2. Estimated daily intake of radionuclides in California diets, September–October 1965 [a]

City	Consumption (kg/capita•day) [b]	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141 cerium-144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	8	0.9	38	0	0	12	2.8	4.0	1.1	0.002
Berkeley	2.1	10	0.6	49	5	4	4	2.1	4.0	0.9	<0.001
Bishop	1.6	11	1.2	60	9	0	0	2.2	3.7	0.8	0.001
Brawley	2.0	9	1.2	44	2	0	2	2.5	4.0	0.7	0.003
Crescent City	2.4	19	0.4	[d]	[d]	[d]	[d]	3.1	5.3	1.1	0.001
Eureka	2.0	24	0.2	82	7	0	0	2.6	2.3	1.6	0.001
Fresno	2.1	14	0.3	106	18	3	0	2.2	3.5	0.9	0.002
Los Angeles	2.6	7	0.5	[d]	[d]	[d]	[d]	2.5	3.4	0.8	0.002
Needles	1.6	8	0.5	39	7	0	0	1.9	2.7	0.7	0.001
Quincy	1.2	4	0.5	37	4	0	0	3.6	2.0	0.4	<0.001
Redding	1.7	7	0.4	50	3	0	0	2.2	3.7	0.6	<0.001
Sacramento	2.5	13	0.8	56	9	0	18	2.8	5.2	1.1	0.001
Salinas	2.4	6	0.3	57	0	0	0	3.0	4.4	0.9	0.002
San Bernardino	2.0	9	0.4	44	4	0	0	2.6	3.7	1.2	0.003
San Diego	1.7	6	0.8	48	3	0	0	2.2	1.9	0.6	0.001
San Luis Obispo	1.1	6	0.6	17	3	4	11	2.0	3.1	0.6	0.001
Santa Barbara	2.1	6	0.3	67	2	0	0	2.6	4.0	0.9	0.002
Santa Rosa	2.3	12	0.8	54	7	0	0	2.2	3.3	1.0	0.001
Susanville	2.0	8	0.4	51	4	0	0	2.3	4.7	0.7	0.002
Ukiah	2.1	12	<0.1	40	2	0	0	2.0	2.4	1.7	0.001

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost.

Table 3. Estimated daily intake of radionuclides in California diets, November–December 1965 [a]

City	Consumption (kg/capita•day) [b]	Intake, pCi/capita • day						Intake, g/capita • day			
		Strontium-90	Radium-226	Cesium-137	Zirconium-95	Manganese-54	Cerium-141 cerium-144	Potassium [c]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	7	0.3	27	4	0	2	2.4	3.5	1.0	<0.001
Berkeley	2.0	10	0.7	42	1	0	0	2.2	3.7	0.9	0.002
Bishop	1.9	32	1.7	55	7	0	3	2.6	3.7	2.0	0.001
Brawley	2.0	9	0.8	32	6	0	4	2.2	3.7	1.0	0.002
Crescent City	2.3	16	0.5	67	11	0	4	2.8	5.0	1.5	0.001
Eureka	2.2	16	0.7	58	4	0	7	2.5	3.7	1.2	0.001
Fresno	2.3	37	0.6	56	5	1	0	2.4	4.0	1.5	0.003
Los Angeles	3.0	11	0.8	49	10	0	2	2.9	4.0	0.8	0.003
Needles	1.8	12	0.2	42	8	0	0	2.4	2.3	1.0	0.001
Quincy	1.3	8	0.3	40	6	0	0	1.5	2.0	0.5	0.001
Redding	2.0	11	0.9	44	7	0	5	2.8	4.9	1.0	0.002
Sacramento	2.8	18	1.8	71	1	0	0	3.4	5.7	1.5	0.002
Salinas	2.4	10	0.9	48	3	0	5	2.8	4.6	0.8	0.001
San Bernardino	2.0	18	0.9	71	1	0	12	2.7	4.0	1.0	0.001
San Diego	2.0	8	0.5	27	5	0	1	2.4	2.5	0.8	0.001
San Luis Obispo	1.4	9	0.6	45	6	0	0	2.0	3.0	0.7	0.001
Santa Barbara	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]	[d]
Santa Rosa	2.5	11	0.4	55	8	0	5	2.8	3.2	1.4	0.001
Susanville	2.0	8	0.2	48	7	0	0	2.3	3.7	0.7	0.001
Ukiah	2.4	10	1.1	52	11	0	0	2.9	3.3	1.5	0.003

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost.

radionuclides in the California diets are given in table 2 (September–October 1965) and table 3 (November–December 1965).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Average strontium–90 intake in the California diet for the September–October 1965 period varied from 4 to 24 pCi/capita • day with an average of 10 pCi/capita • day. Cesium–137 intakes varied from 17 to 106 pCi/capita • day with an average of 52 pCi/capita • day. For the November–December 1965 sampling period, the strontium–90 intake

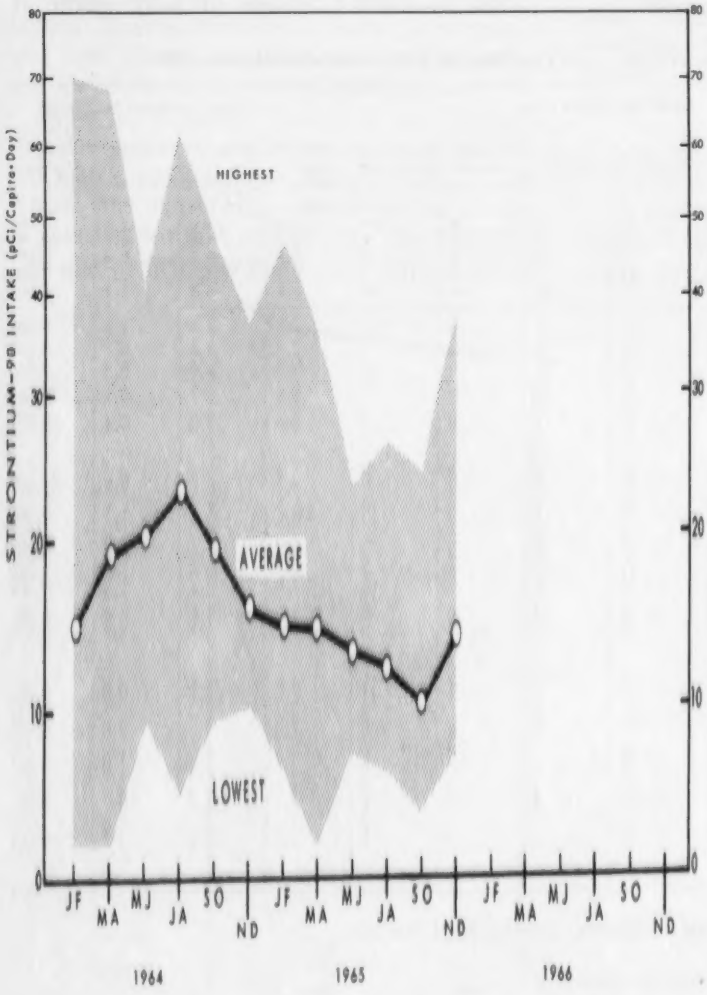

Figure 3. Averages and ranges of daily strontium–90 intake in California diets

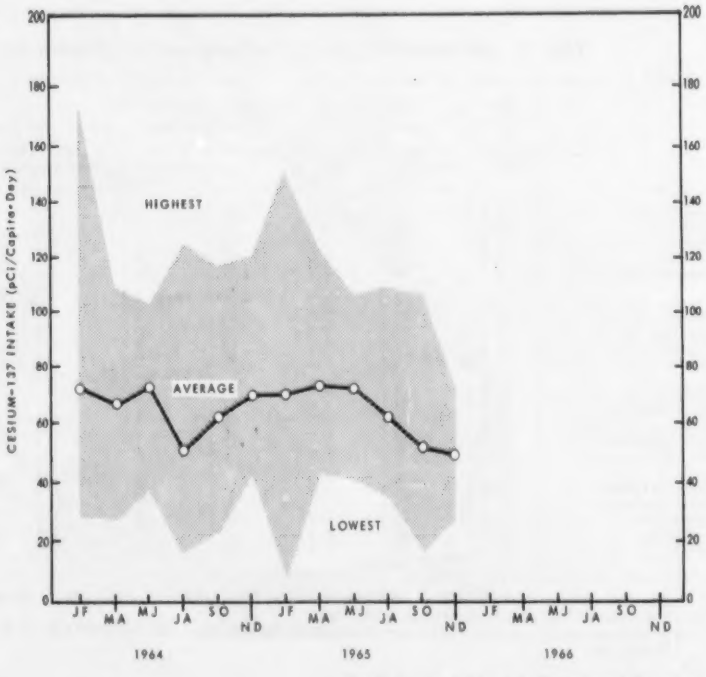

Figure 4. Averages and ranges of daily cesium–137 intake in California diets

varied from 7 to 37 pCi/capita • day with an average of 14 pCi/capita • day. Cesium–137 intakes varied from 27 to 71 pCi/capita • day with an average of 49 pCi/capita • day. A summary of strontium–90 and cesium–137 intake trends in California diets from January 1964 through December 1965 is given in figures 3 and 4.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1964	March and April 1965
July–October 1964	September 1965
November–December 1964	December 1965
January–April 1965	March 1966
May–August 1965	June 1966

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL–144:281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964). Summarized in Rad Health Data 5:285–288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*4*) RIVERA, J. Dietary intakes and body burdens of cesium–137. Rad Health Data 6:504–506 (September 1965).

(*5*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Rad. Health News 4:4 (October 1965). 2151 Berkeley Way, Berkeley 4, California.

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross alpha and gross beta radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guidelines recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Pub 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1966

Basic Data Program
Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The figures for gross alpha and gross beta radioactivity represent either determinations on composites or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and

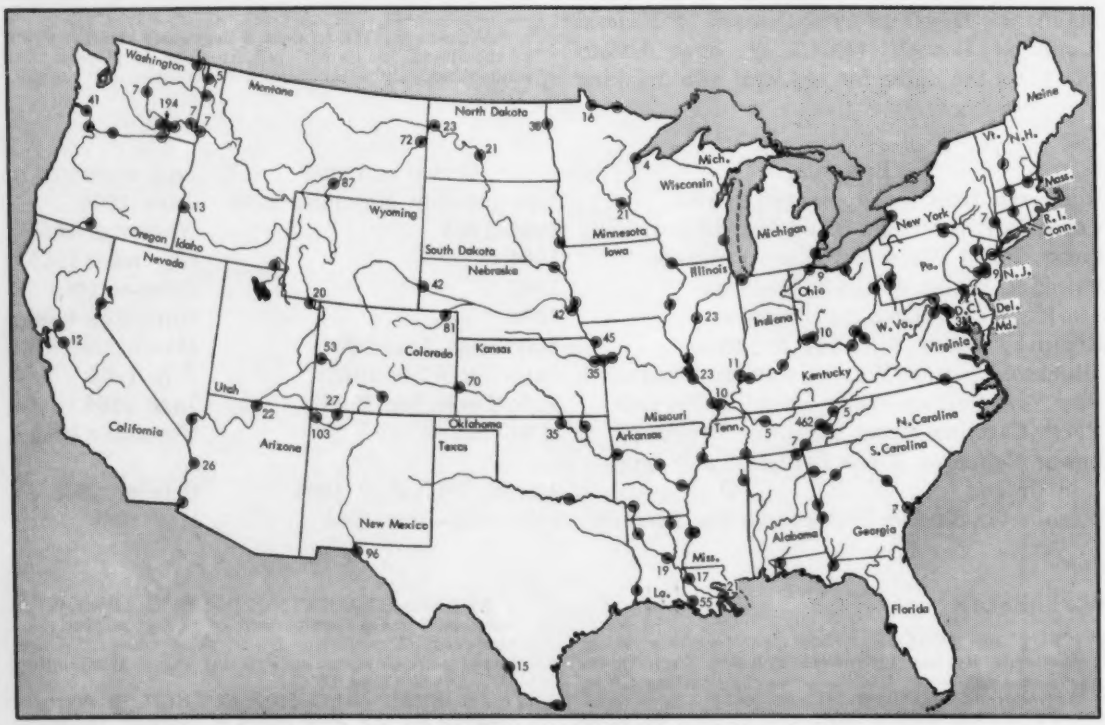

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface water, March 1966

analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations are published in annual compilations (*1-6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During February and March, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River: Henry, Nebraska
Arkansas River: Ponca City, Oklahoma
Arkansas River: Coolidge, Kansas

Julesburg, Colorado, on the South Platte River showed an alpha radioactivity value in excess of 15 pCi/liter on dissolved solids.

Table 1. Radioactivity in raw surface waters, March 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)			Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:							Missouri River:						
Cedar Hill, N. Mex.	18	9	27	3	2	5	Williston, N. Dak.	3	20	23	1	2	3
Arkansas River:							Bismarck, N. Dak.	4	17	21	1	2	3
Coolidge, Kans.	2	68	70	<1	41	41	St. Joseph, Mo.	25	20	45	9	3	12
Ponca City, Okla.	14	21	35	3	13	16	North Platte River:						
Atchafalaya River:							Henry, Nebr.	2	40	42	<1	28	28
Morgan City, La.	47	8	55	12	1	13	Ohio River:						
Big Horn River:							Cairo, Ill.	3	7	10	1	0	1
Hardin, Mont.	72	15	87	35	4	39	Pend Oreille River:						
Chena River:							Albeni Falls Dam,						
Fairbanks, Alaska	<1	3	3	0	<1	<1	Idaho	1	4	5	0	<1	<1
Clearwater River:							Platte River:						
Lewiston, Idaho	4	3	7	<1	0	<1	Plattsmouth, Nebr.	18	24	42	5	7	12
Clinch River:							Potomac River:						
Clinton, Tenn.	0	5	5	0	0	0	Washington, D. C.	0	3	3	1	0	1
Kingston, Tenn.*	8	454	462	0	2	2	Rainy River:						
Colorado River:							Baudette, Minn.	5	11	16	<1	0	<1
Loma, Colo.	34	19	53	9	5	14	Red River, North:						
Page, Ariz.	1	21	22	0	5	5	Grand Forks,						
Parker Dam, Calif.-Ariz.	2	24	26	0	5	5	N. Dak.	7	31	38	1	2	3
Columbia River:							Red River, South:						
Wenatchee, Wash.	1	6	7	0	1	1	Alexandria, La.	7	12	19	2	0	2
Pasco, Wash.*	30	164	194	0	<1	<1	Rio Grande:						
Clatskanie, Ore.	7	34	41	0	<1	<1	Alamosa, Colo.	82	14	96	27	4	31
Cumberland River:							El Paso, Tex.	3	12	15	<1	3	3
Cheatham Lock,							San Joaquin River:						
Tenn.	1	4	5	0	0	0	Vernalis, Calif.	2	10	12	0	2	2
Delaware River:							San Juan River:						
Philadelphia, Pa.	3	6	9	0	0	0	Shiprock, N. Mex.	91	12	103	34	2	36
Green River:							Savannah River:						
Dutch John, Utah	1	19	20	0	2	2	Port Wentworth,						
Hudson River:							Ga.*	1	6	7	0	0	0
Poughkeepsie, N. Y.	1	6	7	0	0	0	Snake River:						
Illinois River:							Payette, Idaho	2	11	13	0	3	3
Peoria, Ill.	12	11	23	3	1	4	Wawawai, Wash.	1	6	7	0	2	2
Kansas River:							South Platte River:						
DeSoto, Kans.	12	23	35	3	5	8	Julesburg, Colo.	9	72	81	2	38	40
Little Miami River:							Susquehanna River:						
Cincinnati, Ohio	1	9	10	0	1	1	Conowingo, Md.	1	3	4	0	0	0
Maumee River:							Tennessee River:						
Toledo, Ohio	0	9	9	0	1	1	Chattanooga, Tenn.	1	6	7	0	0	0
Mississippi River:							Wabash River:						
St. Paul, Minn.	2	19	21	0	1	1	New Harmony, Ind.	3	8	11	<1	1	1
E. St. Louis, Ill.	12	11	23	2	1	3	Yellowstone River:						
New Roads, La.	7	10	17	1	0	1	Sidney, Mont.	52	20	72	12	3	15
New Orleans, La.	12	9	21	4	0	4	Maximum	91	454	462	35	41	41
							Minimum	0	3	3	0	0	0

* Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

During March, the following stations showed a beta radioactivity in excess of 150 pCi/liter on dissolved solids:

Columbia River: Pasco, Washington
Clinch River: Kingston, Tennessee

Since the value reported for Kingston, Tennessee, is somewhat unusual when compared with data for the previous 12 months, special attention has been directed to this station. Further determinations of specific radionuclides are being carried out.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity resulting from intrusions into the atmosphere. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Program	Period reported	Last presented
National Air Sampling Network	January–March 1966	July 1966

1. Radiation Surveillance Network May 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during May 1966. Time profiles of gross beta in air, dating back to 1958, for eight RSN stations are shown in figure 2.

Fresh fission products, presumably from the Chinese nuclear test of May 9, 1966, were detected in network samples collected during May. The first appearance of fresh fission

Figure 1. Radiation Surveillance Network sampling stations

products was at Boise, Idaho, on May 14. This sample contained a gross beta activity of 2.39 pCi/m^3 at the time of collection. The highest air activity was observed at Phoenix, Arizona, on May 20. Extrapolated to time of collection, the activity was 14.87 pCi/m^3, with an estimated age of 12 days.

Gross beta activity in precipitation samples also increased sharply during the latter half of May. The greatest depositions of radionuclides by precipitation were observed in the midwest:

Date May 1966	Location	Precipitation (mm)	Concentration (pCi/liter)	Deposition (pCi/m^2)
18	Indianapolis, Ind	1.8	56.0	102
18	Springfield, Ill	22.5	9.7	219
23	Minneapolis, Minn	4.3	10.4	44
17	Jefferson City, Mo	2.0	124.9	250
18	Jefferson City, Mo	21.5	9.5	204
21	Jefferson City, Mo	19.0	1.0	19
24	Jefferson City, Mo	18.4	4.8	89
20	Lincoln, Neb	10.0	3.4	34
23	Lincoln, Neb	56.3	1.0	57

However, high depositions were observed in other parts of the country such as Augusta, Maine, and various cities in the South.

Table 1. Gross beta activity in surface air and precipitation, May 1966

Station location		Number of samples		Air surveillance			Last profile in *RHD&R*	Precipitation	
				Gross beta activity, pCi/m³				Total depth (mm)	Total deposition (nCi/m²)
		Air	Pptn	Maximum	Minimum	Average [a]			
Ala:	Montgomery	31	10	2.40	<0.10	<0.51	Feb 66	88	<25
Alaska:	Adak	31		0.35	<0.10	<0.11	Jun 66	[b]	
	Anchorage	25	5	0.16	<0.10	<0.11	Mar 66	13	<3
	Attu Islands	11		0.44	<0.10	<0.13	Jul 66	[b]	
	Fairbanks	[c]					Apr 66	[b]	
	Juneau	27	24	<0.10	<0.10	<0.10	Jul 65	263	<53
	Kodiak	6		<0.10	<0.10	<0.10	May 66	[b]	
	Nome	19		<0.10	<0.10	<0.10	Sep 66	[b]	
	Pt. Barrow	31		<0.10	<0.10	<0.10	Aug 66	[b]	
	St. Paul Island	31		<0.10	<0.10	<0.10	Jan 66	[b]	
Ariz:	Phoenix	29		14.87	<0.10	<2.63	Jul 65	[b]	
Ark:	Little Rock	20	2	1.73	<0.10	<0.42	Mar 66	28	<6
Calif:	Berkeley	28	1	0.59	<0.10	<0.13	May 66	3	<1
	Los Angeles	28	1	2.30	<0.10	<0.47	Sep 66	7	<1
C.Z:	Ancon	23		0.98	<0.10	<0.17	May 66	[b]	
Colo:	Denver	28	2	14.29	<0.10	<1.35	May 66	8	<2
Conn:	Hartford	31	11	0.69	<0.10	<0.20	Apr 66	82	<21
Del:	Dover	26		1.83	<0.10	<0.26	Feb 66	[b]	
D.C:	Washington	30	9	1.42	<0.10	<0.26	Aug 66	90	<35
Fla:	Jacksonville	31	21	2.03	<0.10	<0.55	Mar 66	352	<253
	Miami	29	8	2.95	<0.10	<0.86	Apr 66	163	<51
Ga:	Atlanta	[c]					Jan 66	[b]	
Guam:	Agana	31		<0.10	<0.10	<0.10	Feb 66	[b]	
Hawaii:	Honolulu	31	1	2.85	<0.10	<0.46	Jul 66	20	<4
Idaho:	Boise	31	1	4.91	<0.10	<0.65	Jul 66	1	<1
Ill:	Springfield	30	5	2.75	<0.10	<0.35	Aug 66	110	<270
Ind:	Indianapolis	31	7	3.40	<0.10	<0.35	Jan 66	37	<115
Iowa:	Iowa City	30	8	0.45	<0.10	<0.15	May 66	143	<37
Kans:	Topeka	31	4	8.95	<0.10	<0.53	Mar 66	24	<12
Ky:	Frankfort	29	7	1.81	<0.10	<0.20	Aug 66	48	<59
La:	New Orleans	31	10	2.33	<0.10	<0.39	Aug 66	206	<63
Maine:	Augusta	31	10	0.59	<0.10	<0.18	Sep 66	85	<96
	Presque Isle	24	6	0.61	<0.10	<0.15	May 66	74	<15
Md:	Baltimore	28	10	1.48	<0.10	<0.23	Apr 66	74	<22
	Rockville	27		1.88	<0.10	<0.27	Jul 66	[b]	
Mass:	Lawrence	31	11	0.75	<0.10	<0.20	Feb 66	87	<21
	Winchester	29	10	1.28	<0.10	<0.19	Jun 66	93	<19
Mich:	Lansing	31	7	0.57	<0.10	<0.15	Jul 66	50	<21
Minn:	Minneapolis	28	11	0.92	<0.10	<0.17	Feb 66	47	<67
Miss:	Jackson	29	7	3.19	<0.10	<0.60	Sep 66	187	<75
Mo:	Jefferson City	31	9	5.92	<0.10	<0.53	Jan 66	111	<576
Mont:	Helena	30	4	8.97	<0.10	<0.75	Jun 66	15	<4
Nebr:	Lincoln	26	6	3.68	<0.10	<0.31	Jan 66	88	<99
Nev:	Las Vegas	28		6.38	<0.10	<1.74	Apr 66	[b]	
N.H:	Concord	28		0.79	<0.10	<0.18	Aug 66	[b]	
N.J:	Trenton	31	8	1.25	<0.10	<0.23	Sep 66	33	<8
N.Mex:	Santa Fe	30	1	9.91	<0.10	<1.94	Jun 66	4	<1
N.Y:	Albany	24	9	0.30	<0.10	<0.15	Jan 66	68	<16
	Buffalo	31		0.39	<0.10	<0.13	May 66	[b]	
	New York	27		0.56	<0.10	<0.17	Jun 66	[b]	
N.C:	Gastonia	31	9	1.64	<0.10	<0.40	May 66	81	<106
N.Dak:	Bismarck	29	5	3.06	<0.10	<0.24	Aug 66	26	<6
Ohio:	Cincinnati	20		1.53	<0.10	<0.18	Feb 66	[b]	
	Columbus	31	9	2.61	<0.10	<0.34	Sep 66	89	<34
	Painesville	30	5	1.09	<0.10	<0.17	Apr 66	49	<13
Okla:	Oklahoma City	30	3	5.62	<0.10	<0.61	Jul 66	10	<52
	Ponca City	28	4	1.47	<0.10	<0.27	Apr 66	56	<21
Ore:	Portland	26	7	12.17	<0.10	<0.64	Jan 66	16	<3
Pa:	Harrisburg	29	1	0.80	<0.10	<0.19	Jan 66	5	1
P.R:	San Juan	29	3	3.07	<0.10	<0.44	Sep 66	116	<23
R.I:	Providence	28	10	0.87	<0.10	<0.19	Jul 66	103	<22
S.C:	Columbia	28	10	1.93	<0.10	<0.39	Jun 66	116	<32
S.Dak:	Pierre	31	3	4.01	<0.10	<0.40	Jun 66	25	<5
Tenn:	Nashville	31	7	2.52	<0.10	<0.40	Jul 66	76	<86
Tex:	Austin	30	10	0.83	<0.10	<0.28	Feb 66	85	<23
	El Paso	31		6.06	<0.10	<0.95	Aug 66	[b]	
Utah:	Salt Lake City	30	2	9.72	<0.10	1.05	Sep 66	17	<4
Vt:	Barre	31	12	0.83	<0.10	<0.18	Mar 66	61	<13
Va:	Richmond	31	8	1.68	<0.10	<0.34	Mar 66	68	<14
Wash:	Seattle	31	8	<0.10	<0.10	<0.10	Mar 66	26	<5
	Spokane	31	3	6.03	<0.10	<0.47	Feb 66	15	<8
W.Va:	Charleston	30	7	0.69	<0.10	<0.21	Jun 66	53	<14
Wis:	Madison	28	5	1.39	<0.10	<0.17	Mar 66	71	<42
Wyo:	Cheyenne	31	2	7.82	<0.10	<0.80	Apr 66	3	<2
Network summary		2,039	379	14.87	<0.10	<0.41		70	<47

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.
[b] Indicates no report received.
[c] Indicates no precipitation sample collected.

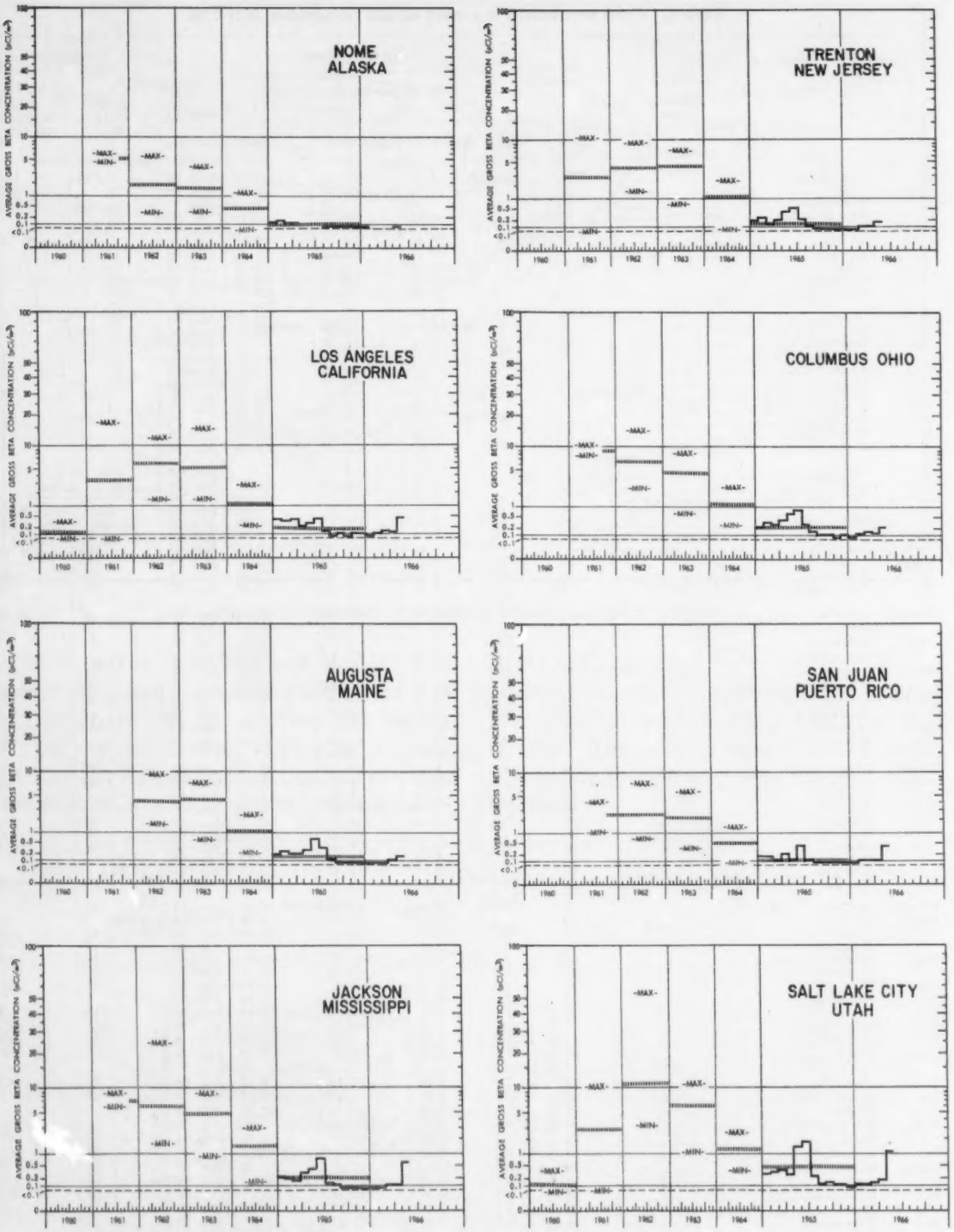

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—May 1966

2. Canadian Air and Precipitation Monitoring Program, May 1966 [1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

[1] Prepared from information and data in the June 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for May 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, May 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	2.2	0.0	0.4	194	16.0
Coral Harbour	30	0.2	0.0	0.1	418	4.0
Edmonton	31	2.6	0.0	0.2	143	4.6
Ft. Churchill	31	0.2	0.0	0.1	107	3.0
Ft. William	31	1.3	0.0	0.1	158	6.8
Fredericton	31	1.0	0.0	0.2	117	6.8
Goose Bay	31	0.2	0.0	0.0	38	3.5
Halifax	31	0.5	0.0	0.2	232	11.9
Inuvik	31	0.1	0.0	0.1	34	1.0
Montreal	31	0.4	0.1	0.2	60	2.3
Moosonee	31	0.3	0.0	0.1	72	3.9
Ottawa	30	2.7	0.0	0.3	115	6.9
Quebec	31	0.6	0.0	0.2	NS	NS
Regina	31	1.4	0.1	0.2	563	14.0
Resolute	31	0.2	0.0	0.1	NS	NS
St. John's Nfld	30	0.2	0.0	0.1	76	8.0
Saskatoon	31	0.3	0.0	0.1	249	3.7
Saulte Ste. Marie	31	0.3	0.0	0.1	54	3.3
Toronto	31	1.5	0.0	0.2	229	11.0
Vancover	31	7.8	0.0	0.3	59	2.2
Whitehorse	31	0.2	0.0	0.1	122	0.7
Windsor	18	2.6	0.0	0.4	296	15.7
Winnipeg	31	5.5	0.0	0.3	1,473	56.1
Yellowknife	31	0.4	0.0	0.1	143	2.4
Network summary		1.4	0.0	0.2	225	8.5

NS, no sample collected.

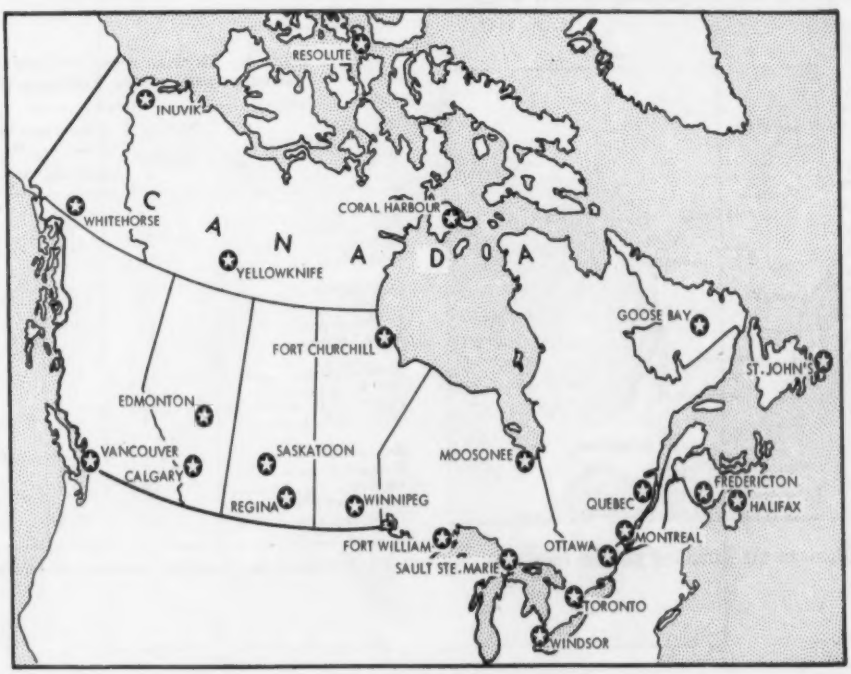

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program
January and February 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México City. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8-12*).

In 1961, the CNEN appointed its Division of Radiological Security (DRS) to establish a new Radiation Surveillance Network. This network consists of 17 stations (figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at México City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México City, while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Figure 4. Mexican air sampling station locations

Details of sampling procedures were presented in the December 1965 issue of *Radiological Health Data*. Samples are counted a minimum of 3 days after collection to allow for decay of radon and thoron. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta activity concentrations in surface air during January and February 1966 are presented in tables 3 and 4, respectively.

Table 3. Mexican gross beta activity of airborne particulates, January 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Ciudad Juárez	18	0.9	0.3	0.6
Chihuahua	17	1.1	0.4	0.7
Ensenada	11	0.8	0.1	0.4
Guadalajara	2	0.3	0.1	
Guaymas	21	0.5	0.2	0.4
La Paz	13	0.4	0.1	0.2
Matamoros	9	1.0	0.1	0.3
Mazatlán	12	0.3	0.2	0.2
Mérida	11	0.2	0.1	0.1
Mexico, D.F.	14	1.2	0.1	0.3
Nuevo Laredo	3	0.2	0.2	0.2
San Luis Potosí	15	0.6	0.1	0.2
Tampico	4	0.1	0.1	0.1
Terréon	12	0.3	0.1	0.2
Tuxtla Gutierrez	NS			
Veracruz	20	0.5	0.1	0.2

NS, no sample collected, station temporarily shut down.

Table 4. Mexican gross beta activity of airborne particulates, February 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.4	0.3	0.3
Ciudad Juárez	20	1.0	0.4	0.7
Chihuahua	8	1.0	0.3	0.6
Ensenada	NS			
Guadalajara	10	0.7	0.1	0.3
Guaymas	5	0.6	0.4	0.5
La Paz	15	0.4	0.1	0.2
Matamoros	NS			
Mazatlán	11	0.3	0.2	0.3
Mérida	8	0.3	0.1	0.2
Mexico, D.F.	20	0.4	0.1	0.2
Nuevo Laredo	1	0.1	<0.1	<0.1
San Luis Potosí	1	0.1	<0.1	<0.1
Tampico	5	0.4	0.1	0.1
Terréon	18	0.4	0.1	0.2
Tuxtla Gutierrez	NS			
Veracruz	15	0.3	0.1	0.2

NS, no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program May 1966

Pan American Health Organization
and *U.S. Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed by the Radiation Surveillance Network. The air sampling positions are shown in figure 5.

The May 1966 air monitoring results from the participating countries are given in table 5.

Table 5. PAHO gross beta activity in surface air, May 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	<0.10	<0.10	<0.10
Chile: Santiago	23	<0.10	<0.10	<0.10
Jamaica: Kingston	25	1.32	<0.10	<0.32
Peru: Lima	16	<0.10	<0.10	<0.10
Venezuela: Caracas	21	0.12	<0.10	<0.10
West Indies: Trinidad	20	0.11	<0.10	<0.10
Pan American summary	120	1.32	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.

Figure 5. Pan American Air Network sampling stations

5. Fallout in the United States and Other Areas July–December 1965[2]

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and 35 other selected points in the Western Hemisphere (figure 6) covering the period from July through December 1965, are summarized in tables 6 and 7. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

To facilitate the accurate storage, retrieval, and handling of data generated from the monthly fallout collections network, all data obtained are transcribed onto punched cards. To accomplish this transcription, several rigid criteria were applied to the data. One condition was that only monthly data were punched onto the cards. In the few cases where collections were incomplete or where collection times overlapped calendar months, the data were corrected to yield monthly values by interpolation using rainfall and observed concentrations in rainfall as guides. Where any corrections to the data have been made, they are so indicated. In every case, the best estimate of the true strontium–90 deposition is listed.

[2] The data in this article were taken from Fallout Program Quarterly Summary Report, HASL 172:A–1–A–164; B–1–B–21 (July 1, 1966).

Table 6. Strontium-90 fallout in the United States, HASL, July–December 1965

Sampling location and type of collection		Deposition, nCi/m²					
		July	Aug	Sept	Oct	Nov	Dec
Ala:	Birmingham (pot)	0.96	0.22	0.36	0.05	0.15	0.20
Alaska:	Anchorage (col)	0.35	0.40	0.29	0.05	0.12	NS
	Barrow (col)	*0.06	*0.07	T	0.02	0.07	0.02
	Cold Bay (col)	0.46	0.29	1.10	0.15	NS	0.46
	Fairbanks (col)	0.25	0.29	0.14	0.28	0.06	NS
	Juneau (col)	0.27	0.31	1.55	NS	0.08	0.18
	Nome (col)	0.05	0.03	NS	*0.02	*0.01	0.01
Calif:	W. Los Angeles (pot)	0.05	0.05	0.11	0.01	0.54	0.09
	Palo Alto (pot)	0.02	0.02	0.02	T	0.55	0.18
	San Francisco (col)	0.01	T	0.01	T	0.25	0.41
Colo:	Denver (col)	0.67	0.13	0.24	0.02	T	0.61
Fla:	Coral Gables (pot)	0.36	0.43	0.29	0.18	0.04	0.08
	Miami (col)	0.48	0.22	0.12	0.17	T	1.12
Hawaii:	Hilo (col)	NS	0.70	0.23	0.26	0.73	0.13
	Honolulu (pot)	0.39	0.14	0.20	0.25	0.01	0.30
	Lihue (col)	0.16	0.14	0.13	NS	0.25	0.10
	Mauna Loa (col)	0.07	T	0.07	0.04	0.02	0.03
Ill:	Argonne (pot)	0.36	0.39	0.59	0.15	0.07	0.17
La:	New Orleans (col)	0.30	0.27	0.25	0.05	0.06	0.11
Minn:	International Falls (col)	0.56	0.25	0.44	0.07	0.05	0.04
Mo:	Columbia (col)	0.32	0.28	0.58	0.18	0.20	0.08
Mont:	Helena (col)	0.53	0.20	0.25	0.10	0.05	0.05
N.J:	Westwood (pot)	0.62	0.34	0.15	0.18	0.18	0.13
N.Y:	New York (pot)	0.55	0.39	0.11	0.19	0.15	0.11
N.Dak:	Williston (col)	0.46	0.30	0.30	NS	0.09	0.09
Ohio:	Wooster (pot)	0.18	0.30	0.54	0.03	0.11	0.06
Okla:	Midwest City (pot)	0.63	0.71	0.17	0.06	0.07	0.44
	Tulsa (pot)	NS	0.27	0.31	0.05	0.04	0.24
Ore:	Medford (col)	0.05	0.32	0.02	0.10	0.11	0.22
S.C:	Columbia (col)	0.48	0.35	0.23	0.22	0.10	0.01
S. Dak:	Vermillion (pot)	1.21	0.36	0.62	0.08	1.32	0.08
Tenn:	Chattanooga (pot)	0.39	0.16	0.12	0.08	0.25	0.06
Tex:	Dallas (col)	T	0.10	0.91	0.07	0.06	0.07
	El Paso (col)	0.12	0.11	0.18	0.06	0.04	0.19
	Houston (col)	0.16	0.12	0.12	0.22	0.12	0.15
Utah:	Salt Lake City (pot)	0.18	0.32	0.27	0.08	0.13	0.15
Va:	Sterling (col)	0.68	0.24	0.10	0.08	0.10	0.08
Wash:	Seattle (pot)	0.10	0.25	0.09	0.11	0.22	0.26
	Seattle (pot)	0.10	0.51	0.20	0.08	0.30	0.35
	Tatoosh Island (col)	0.11	0.13	0.30	0.37	0.27	0.51
Wis:	Appleton (pot)	0.32	0.51	0.27	0.17	0.20	0.17
	Green Bay (col)	0.54	0.46	0.46	0.04	0.14	0.33

* Proportioned from originally consolidated data.
NS, no sample reported.
T, trace or zero

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 7. Strontium-90 fallout in North and South America, HASL, July–December 1965

Sampling location and type of collection		Deposition, nCi/m²					
		July	Aug	Sept	Oct	Nov	Dec
Argentina:	Buenos Aires (col)	0.07	0.08	0.17	0.20	0.12	0.13
	Formosa (col)	0.02	0.12	0.13	0.16	0.13	0.22
	Malargue (col)	0.03	0.08	0.02	0.08	0.04	NS
Bermuda:	Kindley AFB (col)	0.03	0.07	0.16	0.05	0.06	T
Bolivia:	Chacaltaya (col)	0.01	0.01	0.03	0.07	0.06	T
	La Paz (Ovejuyo) (col)	T	0.03	0.03	0.02	0.10	T
	La Paz (city) (col)	T	0.30	0.04	0.05	0.03	0.05
Brazil:	Belem (col)	0.03	0.03	0.07	0.07	0.14	0.35
	Brasilia (pot)	T	T	T	NS	NS	NS
	Itaici Sao Paulo (pot)	0.03	0.02	0.09	0.02	NS	NS
	Nova Friburgo (pot)	0.01	0.07	0.06	0.18	T	0.28
	Rio de Janeiro (col)	0.27	0.86	0.31	0.21	0.04	0.13
	San Jose Dose Campos (pot)	0.03	T	0.02	0.05	NS	NS
	Sao Leopoldo (pot)	0.12	0.16	0.37	NS	0.13	0.13
	Trinidade Island (col)	0.05	0.12	0.10	T	T	NS
Canada:	Newfoundland (col)	0.29	0.38	0.28	0.15	T	0.07
	Moosonee (col)	0.71	0.40	0.20	0.29	0.08	0.03
Canal Zone:	Miraflores (col)	0.05	0.07	0.07	0.05	0.04	0.21
Chile:	Antofagasta (col)	T	0.02	T	NS	NS	NS
	I. Alejandro Selkirk (col)	T	0.69	0.10	0.22	0.08	NS
	Easter Island (col)	0.10	0.10	NS	NS	NS	NS
	Puerto Montt (col)	0.26	0.36	0.11	0.22	T	NS
	Punta Arenas (col)	0.07	0.10	0.03	0.02	0.08	0.05
	Santiago (pot)	0.39	0.05	0.21	NS	NS	0.05
	Santiago (col)	0.48	0.17	T	0.06	0.28	0.45
Colombia:	Bogota (pot)	T	0.01	NS	NS	NS	NS
Costa Rica:	Turrialba (col)	0.61	0.08	0.06	0.02	0.04	0.03
Equador:	Guayaquil (col)	NS	NS	NS	NS	0.14	0.11
	Quito (col)	0.01	0.01	T	0.02	T	0.10
Greenland:	Thule (col)	0.17	0.13	0.11	0.01	0.02	NS
Iceland:	Keflavik (col)	0.14	0.13	0.10	0.46	0.05	0.07
Mexico:	Mexico City (col)	0.17	0.06	0.01	0.09	T	0.03
Peru:	Lima (col)	*0.01	T	0.13	0.05	0.04	0.15
	Lima (col)	*0.01	*0.03	0.13	0.06	T	NS
Puerto Rico:	San Juan (col)	0.32	0.32	0.20	0.10	0.05	0.14
Venezuela:	Caracas (site 1) (col)	0.12	0.16	0.37	T	T	NS
	Caracas (site 2) (col)	NS	NS	0.07	0.06	T	T

* Indicates proportioned from originally consolidated data.
T, trace or zero.
NS, no sample reported.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m². At the end of the collection period, the contents are transferred by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m², attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods.

Other radionuclides

Laboratories at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have analyzed monthly pot samples for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium–89, strontium–90, cesium–137, cerium–144, zirconium–95, manganese–54, and iron–55 at each station are presented in table 8. In June 1965, routine reporting of manganese–54, strontium–89, zirconium–95, and cesium–137 was discontinued for the above locations. The reported depositions of manganese–54 and iron–55 have been corrected for decay to October 15, 1961. The remaining radionuclide data have been corrected for decay to the midpoint of the sampling month.

Table 8. HASL, radiochemical analyses of pot fallout samples at 6 U.S. sites, fission product and "tracer" radionuclides in monthly collections, July–December 1965

Sampling location	Precipitation, mm						Iron-55, nCi/m²					
	July	Aug	Sept	Oct	Nov	Dec	July	Aug	Sept	Oct	Nov	Dec
California, Palo Alto	T	T	T	T	122.9	81.3	1.26	<0.39	0.88	<0.17	5.21	1.87
New Jersey, Westwood	80.0	116.1	77.2	61.2	47.8	43.4	4.79	3.22	1.40	1.74	2.22	1.49
Oklahoma, Oklahoma City	48.3	127.5	106.4	33.5	1.0	68.6	5.87	8.07	2.96	0.80	1.35	4.21
Tennessee, Chattanooga	114.6	115.3	117.6	22.6	101.3	21.3	3.28	1.41	1.29	1.13	2.52	0.96
Washington, Seattle [a]	11.9	39.1	21.1	45.7	120.6	144.3	<0.54	2.59	1.11	0.92	1.82	0.02
Wisconsin, Appleton	63.5	94.2	199.9	47.5	47.2	67.0	2.79	4.71	3.13	1.64	2.64	1.94
	Strontium-90, nCi/m²						Cerium-144, nCi/m²					
California, Palo Alto	0.02	0.02	0.02	T	0.55	0.18	0.11	0.05	0.10	0.03	1.24	0.66
New Jersey, Westwood	0.62	0.34	0.15	0.18	0.18	0.13	1.95	1.15	0.48	0.52	0.47	0.27
Oklahoma, Oklahoma City	0.63	0.71	0.17	0.06	0.07	0.44	2.58	2.31	0.63	0.21	0.24	1.74
Tennessee, Chattanooga	0.39	0.16	0.12	0.08	0.25	0.06	1.55	0.56	0.32	0.27	0.55	0.20
Washington, Seattle	0.10	0.25	0.09	0.11	0.22	0.26	0.54	1.20	0.37	0.38	1.02	0.50
Wisconsin, Appleton	0.32	0.51	0.27	0.17	0.20	0.17	1.71	1.73	0.83	0.47	0.42	0.47

[a] Only Seattle samples analyzed for manganese-54, strontium-89, zirconium-95, and cesium-137, the results for July and August being respectively as follows: 0.72, 1.58; 0.07, 0.07; 0.07, 0.03, 0.19, and 0.39 nCi/m³.
T, trace or zero.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, APRIL–JUNE 1965[1]

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available for older children, but it presents some difficulties in the case of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for analysis as a basis for comparison with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. Procedures of sample collection and preparation were presented earlier (*2*). Strontium–90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of analytical quality control, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, specially prepared animal and adult human bone ash are analyzed in replicate as a continuing check on analytical sensitivity and accuracy.

[1] Period during which deaths or surgical procedures occurred.

Table 1. Strontium-90 in human bone, deaths or surgical procedures during April–June 1965

Sampling region and State	Sex	Bone type[a]	Age at death[b] (years)	Strontium-90, pCi/g of: Ash	2σ error	Calcium	Bone
Northeast:							
Mass.	F	V	0(11 mo)	1.57	0.19	4.78	0.12
Mass.	M	V	4	0.81	0.10	2.35	0.06
Mass.	F	V	5	1.16	0.13	3.36	0.08
Mass.	M	V	6	1.38	0.13	3.97	0.12
N.Y.	M	V	6	1.69	0.13	4.71	0.15
Mass.	M	V	7	0.87	0.10	2.39	0.09
Mass.	F	V	7	1.40	0.14	4.08	0.11
Mass.	F	V	8	1.16	0.11	3.15	0.13
Mass.	F	V	9	1.89	0.12	5.51	0.26
Mass.	M	V	10	0.71	0.08	1.98	0.07
Mass.	M	V	10	0.95	0.08	2.69	0.09
N.Y.	M	V	12	0.71	0.07	1.94	0.08
Mass.	F	V	12	0.93	0.10	2.56	0.12
Mass.	F	V	13	1.04	0.07	2.88	0.12
Mass.	F	V	13	1.34	0.12	3.62	0.12
Mass.	F	V	13	1.07	0.07	3.02	0.11
Mass.	F	V, R	15	1.02	0.07	2.90	0.10
N.Y.	M	V	15	0.65	0.07	1.77	0.08
Mass.	F	V	16	0.79	0.06	2.11	0.10
Mass.	M	V	16	0.96	0.07	2.57	0.13
N.Y.	M	V	18	0.78	0.06	2.14	0.10
N.Y.	M	V	18	0.64	0.06	1.67	0.09
N.Y.	M	V	18	0.57	0.05	1.52	0.06
Mass.	M	V	20	0.98	0.06	2.64	0.10
N.Y.	F	V	21	0.48	0.05	1.26	0.07
Mass.	F	V	21	0.86	0.06	2.21	0.16
Mass.	M	V	22	0.93	0.07	2.47	0.13
N.Y.	M	V	22	0.97	0.07	2.59	0.12
N.Y.	M	V	23	0.56	0.05	1.49	0.08
Pa.	M	V	24	0.87	0.08	2.30	0.09
Mass.	M	V	25	0.90	0.06	2.35	0.14
N.Y.	F	V	25	0.55	0.05	1.48	0.06
Central:							
Wis.	F	V	0(9 mo)	2.04	0.20	5.43	0.24
Wis.	M	V	0(9 mo)	2.01	0.21	5.73	0.16
Ohio	M	V	1	1.59	0.17	4.31	0.17
Wis.	M	V	2	0.96	0.09	2.74	0.09
Wis.	F	V	2	1.06	0.13	3.03	0.09
Ohio	F	V	3	2.12	0.15	5.45	0.43
Wis.	F	V	3	1.32	0.12	3.71	0.10
Minn.	M	V	3	1.98	0.18	5.40	0.18
Wis.	M	V	5	0.93	0.07	2.56	0.08
Ohio	M	V	6	0.95	0.11	2.38	0.13
Minn.	F	V	10	1.49	0.10	4.06	0.14
Minn.	M	V	11	1.91	0.11	5.19	0.14
Ohio	M	V	11	1.05	0.11	2.87	0.18
Ohio	F	V	11	0.82	0.08	2.21	0.14
Ohio	M	V	12	0.90	0.08	2.32	0.15
Ohio	F	V	12	0.89	0.08	2.30	0.14
Ohio	F	V	12	1.12	0.06	3.00	0.20
Ohio	F	V	14	0.99	0.06	2.52	0.15
Ohio	M	V	15	0.96	0.06	2.49	0.19
Minn.	F	V	15	0.62	0.05	1.61	0.09
Minn.	M	V	16	0.78	0.06	2.13	0.09
Ohio	M	V	18	0.86	0.06	2.23	0.15
Ohio	M	V	18	1.04	0.06	2.65	0.18
Ohio	M	V	19	0.76	0.06	1.94	0.13
Ohio	M	V	21	0.89	0.06	2.27	0.17
Ohio	M	V	22	0.75	0.06	1.92	0.10
Ohio	F	V	23	0.78	0.06	1.96	0.14
Ohio	M	V	23	0.85	0.05	2.22	0.14
Ohio	M	V	24	0.74	0.06	1.94	0.14
Ohio	M	V	24	0.63	0.05	1.66	0.09
Ohio	M	V	25	0.55	0.04	1.40	0.10
Delta:							
La.	F	V	2	2.56	0.17	7.07	0.29
La.	M	V, R	2	2.13	0.16	5.74	0.20
La.	F	V	5	2.40	0.11	6.40	0.31
La.	M	F	9	1.00	0.07	2.55	0.12
La.	M	R	10	1.30	0.10	3.46	0.26
La.	M	R	12	1.09	0.11	2.82	0.20
La.	F	V, R	16	0.48	0.06	1.25	0.08
La.	M	V	22	1.07	0.07	2.77	0.16
La.	M	V, R	24	0.53	0.05	1.42	0.08
Northwest:							
Alaska	F	R	12	1.25	0.19	3.13	0.39
Alaska	F	R	17	1.76	0.16	4.31	0.65
Alaska	F	R	25	0.46	0.13	1.17	0.16
Southwest:							
Calif.	F	V, R	0(13 da)	0.46	0.06	1.23	0.05
Calif.	F	V, R	0(2 mo)	0.97	0.10	2.98	0.05
Ariz.	M	V	1	1.21	0.09	3.27	0.14
Calif.	M	V, R	1	1.32	0.10	3.60	0.12
Calif.	F	V	2	1.63	0.19	4.54	0.17
Calif.	F	V	5	1.20	0.11	3.58	0.06
Calif.	M	V	16	0.90	0.09	2.48	0.11
Tex.	M	V	17	0.65	0.09	1.72	0.07

[a] Type of bone: V, vertebrae; R, rib; F, femur.

[b] Age given as of last birthday prior to death.

The results of laboratory analyses for strontium–90 in individual bones from persons dying during the second quarter of 1965 are presented in table 1 in order of increasing age within each sampling region. The sampling regions have been defined in an earlier report (*5*). The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development), and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Table 2 summarizes the average concentrations of strontium–90 in human bone by 5-year age groups for each year from 1961 through the first half of 1965.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2-4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1962–1964	April 1966
First quarter 1965	June 1966

Table 2. Strontium-90 in human bone samples for 5-year groups, 1961–1964 and first half 1965

Age group [a]	Year of death [b]	Number	Strontium-90, pCi/g calcium		
			Mean [c]	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965, first half	38	4.1	1.2	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965, first half	26	3.0	1.3	6.4
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965, first half	24	3.0	1.6	5.2
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965, first half	28	2.3	1.3	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965, first half	25	1.9	1.0	2.8

[a] Age taken as of last birthday prior to death; ages greater than 24 years not included.
[b] Or surgical procedure.
[c] Mean values given in this table for the various years within each age group may not be directly comparable because of variations in sampling locations from year to year; however, the data are given as a summary of presently available known results.

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(4) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium–90 in human bone. Rad Health Data 5:620–628 (December 1964).

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory, Atomics International, National Reactor Testing Station, and the Oak Ridge Area.

[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." These are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Argonne National Laboratory July–December 1965 [3]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually dispersed by air and water, the environmental monitoring program at Argonne has concentrated on these media. The sampling locations discussed in this report are shown in figures 1 and 2.

[3] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1965," University of Chicago, Lemont, Illinois.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. Sampling on charcoal for radioactive iodine was conducted on the site only. Iodine–131 concentrations greater than the detection limit of 0.1 pCi/m^3 were found in the onsite samples during portions of July, August, October, and November. The maximum concentration in any one sample was 10 pCi/m^3, or 10 percent of the AEC standard. The iodine–131 was accidentally released from two of the Argonne buildings in the 300 area. Surface deposition was confined to within 1,000 yards of the point of release. None was detected off the site. The average iodine–131 concentration for the entire year was about 0.3 pCi/m^3, or 0.3 percent of the AEC standard.

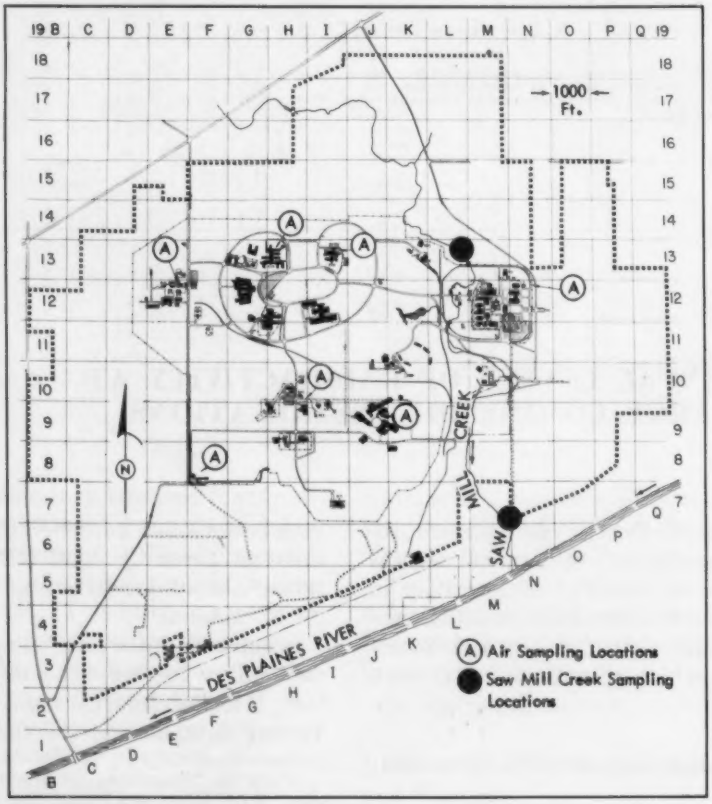

Figure 1. Sampling locations on the site of Argonne National Laboratory

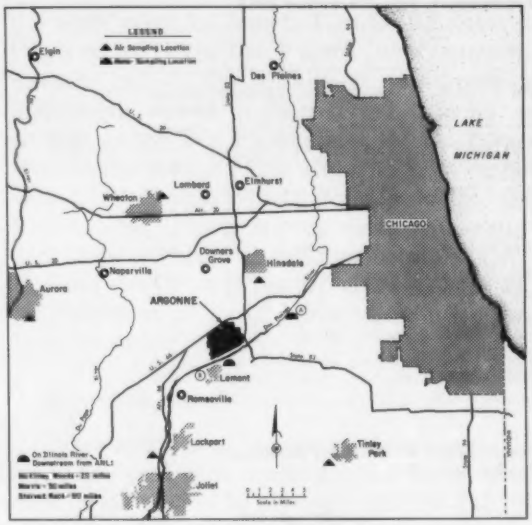

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

The total alpha and beta activities in the air-filter samples are summarized in table 1. The alpha activities were normal both on and off the site and were in the range found in previous years. The beta activity was due primarily to fission and neutron activation products from nuclear detonations. Activity from the Chinese atmospheric nuclear detonation of May 14, 1965, was observed on the air-filter samples from May 21 through July. The average beta activity for the year, 0.25 pCi/m^3, was about one-fourth of the 1964 average. The similarity between alpha and beta activities on and off the site indicates that Argonne did not add significantly to the particulate airborne activity of the environment. The concentrations of specific fission products given in table 2 support this conclusion. Significant releases by Argonne would have been detected in the form of an increase in the onsite levels over the offsite levels.

Water monitoring

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the waste water on the radioactivity in the creek. Radioactivity from Argonne waste water, in amounts well below the AEC standards, was found in some samples of Sawmill Creek water collected below the discharge. The concentrations of radioactive materials at this location are summarized in table 3. The table gives the average and max-

Table 1. Total alpha and beta activities in air-filter samples, July–December 1965 [a]

Month 1965	Location	Number of samples	Alpha activity, pCi/m^3			Beta activity, pCi/m^3		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	27	0.0042	0.0027	0.0064	0.37	0.17	0.65
	Offsite	22	0.0046	0.0022	0.0095	0.39	0.20	0.73
August	Onsite	28	0.0049	0.0022	0.0071	0.16	0.09	0.23
	Offsite	23	0.0035	0.0017	0.0052	0.17	0.08	0.25
September	Onsite	24	0.0033	0.0022	0.0061	0.09	0.03	0.25
	Offsite	18	0.0029	0.0014	0.0084	0.08	0.05	0.12
October	Onsite	26	0.0035	0.0021	0.0063	0.09	0.05	0.41
	Offsite	22	0.0032	0.0018	0.0054	0.08	0.05	0.11
November	Onsite	27	0.0047	0.0027	0.0082	0.08	0.05	0.13
	Offsite	22	0.0042	0.0028	0.0060	0.08	0.06	0.10
December	Onsite	25	0.0044	0.0029	0.0063	0.08	0.04	0.12
	Offsite	19	0.0046	0.0028	0.0072	0.09	0.05	0.18
Summary	Onsite	157	0.0042	0.0021	0.0082	0.15	0.03	0.65
	Offsite	126	0.0038	0.0014	0.0095	0.15	0.05	0.73
Annual summary	Onsite	306	0.0039	0.0004	0.0082	0.24	0.03	1.13
	Offsite	241	0.0039	0.0013	0.0095	0.25	0.05	1.20

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within 4 days by radioactive decay.

Table 2. Gamma-ray activity in air-filter samples, July–December 1965

Nuclide	Location	Gamma air activity, pCi/m³							
		July	Aug	Sept	Oct	Nov	Dec	Average	Annual average
Antimony-125	Onsite	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Offsite	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Barium-lanthanum-140	Onsite	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02
	Offsite	<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02
Cerium-144	Onsite	0.11	0.05	0.03	0.01	0.01	0.01	0.04	0.08
	Offsite	0.12	0.06	0.02	0.01	0.01	0.01	0.04	0.08
Cesium-137	Onsite	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02
	Offsite	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02
Ruthenium-rhodium-106	Onsite	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
	Offsite	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
Zirconium-niobium-95	Onsite	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Offsite	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Table 3. Radioactivity in Sawmill Creek water below waste-water discharge July–December and calendar year 1965

Nuclide	July–December 1965				Calendar year 1965			
	Concentration (pCi/liter)		Percent of AEC Standard		Concentration (pCi/liter)		Percent of AEC standard	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Barium-140	—	<2	—	<0.007	—	<2	—	<0.007
Cesium-137	1.8	3.4	0.009	0.017	1.5	3.4	0.008	0.017
Cobalt-58	—	<5	—	<0.005	—	<5	—	<0.005
Cobalt-60	<1	1.5	<0.002	0.003	1.0	14.1	0.002	0.028
Hydrogen-3 (tritium)	<4,000	6,000	<0.13	0.2	<4,000	6,000	<0.13	0.2
Iodine-131	—	<3	—	<1	—	<3	—	<1
Plutonium	0.09	0.95	0.002	0.019	0.06	0.95	0.001	0.019
Strontium-89	—	<2	—	<1.07	—	<2	—	<0.07
Strontium-90	2.0	4.7	0.67	1.6	2.4	5.5	0.80	1.8
Technetium-99	—	<0.5	—	<0.0002	—	<0.5	—	<0.0002
Thorium-232	0.09	1.1	0.005	0.055	0.10	1.1	0.005	0.055
Thorium-protactinium-234	2.1	4.7	0.011	0.024	1.7	7.7	0.009	0.039
Uranium	2.6	5.9	0.007	0.015	2.7	10.6	0.007	0.027

imum concentrations in pCi/liter, as well as the corresponding percentage of the AEC standards.

A comparison of these concentrations with those above the discharge indicates that essentially all of the thorium, plutonium, cesium–137, cobalt–60, and tritium, and about two-thirds of the thorium–234 and uranium originated in the waste water, while most of the strontium–90 was due to fallout.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in these two streams is important in determining the effect of Argonne operations on the environmental radioactivity. The alpha, beta, and uranium activities found in these streams are summarized in table 4. Des Plaines River water was also analyzed for the other nuclides found in Sawmill Creek, and, as was the case for the results in table 4, no significant differences in radioactivity between sampling locations of

Table 4. Average radioactivity in Des Plaines and Illinois River water, July–December and calendar year 1965

Location	July–December 1965			Calendar year 1965		
	Alpha activity (pCi/liter)	Uranium (pCi/liter)	Beta activity (pCi/liter)	Alpha activity (pCi/liter)	Uranium (pCi/liter)	Beta activity (pCi/liter)
Des Plaines River [a] (above Sawmill Creek)	2.7	2.3	16	2.4	2.1	18
Des Plaines River [b] (below Sawmill Creek)	2.7	2.2	15	2.4	1.9	18
Illinois River [c]	2.4	2.0	8	2.4	2.1	11

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average of two sampling locations: McKinley Woods State Park and Morris. See figure 2 for all sampling locations.

the river could be found. Dilution of Sawmill Creek water in the Des Plaines River was sufficient to reduce the activity in the Creek to undetectable levels in the river. The alpha activities in the Des Plaines and Illinois Rivers were in the normal range and similar to earlier values. The natural beta activity in the Des Plaines and Illinois Rivers varies between 5 and 10 pCi/liter. The additional beta activity in these streams was due to fallout. There was no indication of activity from Argonne operations in either stream.

Milk monitoring

Three samples of locally produced raw milk were analyzed each month for the fission products most likely to be present. Barium–140 and strontium–89 were found only in the June samples, at average concentrations of 24 and 14 pCi/liter, respectively. These activities are assumed to have originated in the Chinese test of May 14, 1965. Cesium–137 and strontium–90 were present in most samples during the year. Their average concentrations were 47 and 12 pCi/liter, respectively. The average strontium–90 concentration was similar to that of 1964, while the cesium–137 concentration decreased by about a factor of four. These fission products were due to fallout from nuclear detonations and were not related to Argonne operations.

Summary

Fallout activity was present in all types of samples and at all locations throughout the year, but in much lower concentrations than in 1964. Argonne's contribution to the environment was confined to Sawmill Creek below the wastewater discharge and to radioiodine detected in air and grass collected on the Argonne site. The concentrations of radioactive substances added to the environment during the year by Argonne were considerably less than the AEC standards and did not constitute a health hazard.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1961	May 1962
Calendar year 1962	May 1963
Calendar year 1963	August 1964
January–June 1964	March 1965
July–December 1964	September 1965
January–June 1965	March 1966

2. Atomics International July–December 1965 [4]

North American Aviation, Inc.
Canoga Park, California

Atomics International, a Division of North American Aviation, Inc., has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air

[4] Summarized from "Environmental Monitoring, Semiannual Report, January 1 to June 30, 1965," Atomics International.

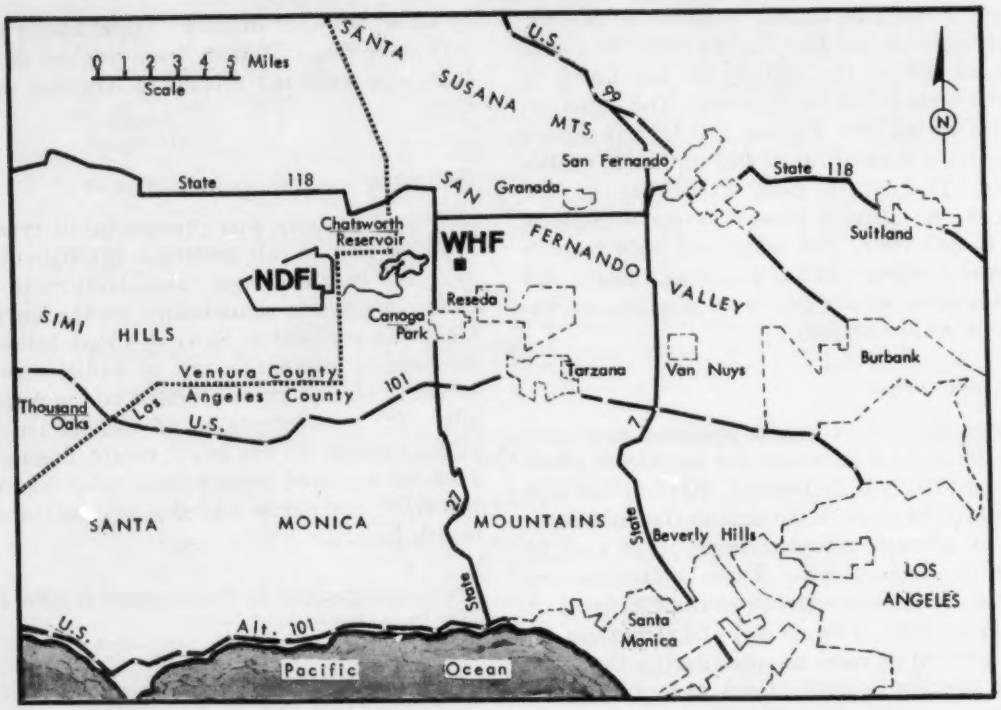

Figure 3. Atomics International facilities and vicinity

monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV–70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 29 cubic meters. The average concentration of airborne particulates is presented in table 5.

Water monitoring

Process water used at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well water radioactivity is presented in table 6.

Soil, vegetation, and water are sampled monthy at Chatsworth Reservoir, which is operated by the Los Angeles City Department of

Table 5. Beta-gamma radioactivity of airborne particulates, NDFL, 1965

Location	First half 1965		Second half 1965	
	Number of samples	Average concentration (pCi/m³)	Number of samples	Average concentration (pCi/m³)
Headquarters	182	2.0	301	0.12
NDFL	69	1.9	993	0.09

Table 6. Well water radioactivity, NDFL, 1965

Activity	First half 1965		Second half 1965	
	Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.22	12	<0.22
Beta-gamma	12	<6.5	12	5.5

Water and Power. Soil and vegetation radioactivity data for the reservoir are averaged into data presented in tables 7 and 8. Normally,

Table 7. Radioactivity in the soil, NDFL, 1965

Area	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/g)	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.49	72	<0.44
	Beta-gamma	72	40	72	32
Offsite	Alpha	70	<0.51	72	<0.45
	Beta-gamma	70	30	72	27

Table 8. Radioactivity in vegetation, NDFL, 1965

Area	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/g ash)	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	<0.62	72	<0.50
	Beta-gamma	72	177	72	146
Offsite	Alpha	70	0.78	72	<0.46
	Beta-gamma	70	156	72	121

one water sample is obtained from the lake surface and a second sample is obtained from the reservoir supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 9.

Table 9. Chatsworth Reservoir water radioactivity, 1965

Sample	Activity	First half 1965		Second half 1965	
		Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	6	0.53	5	0.81
	Beta-gamma	6	9.8	5	7.3
Supply inlet	Alpha	6	0.44	6	0.78
	Beta-gamma	6	12.2	6	<5.9

In the laboratory, 500 ml of water is evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred to stainless-steel planchets, wetted with distilled water to produce a uniform sample distribution, redried under infrared lamps, and counted.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as onsite stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as offsite stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis.

Sample preparation consists of transferring the soils to Pyrex beakers and drying in a muffle furnace at 500°C. for approximately 8 hours. After cooling, the soil is sieved to obtain a uniform particle size. One-gram aliquots of the sieved soil are weighed and transferred to stainless-steel planchets. The soil is wetted in the planchet with acetone, agitated to obtain uniform sample thickness, re-dried, and counted. Radioactivity in soil is presented in table 8.

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season that do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and placed in ice cream cartons for transfer to the laboratory for analysis. Plant root systems are not routinely sampled.

Vegetation samples are first washed with tap water to remove foreign matter and then thoroughly rinsed in distilled water. Washed vegetation is placed in porcelain crucibles and ashed in a muffle furnace at 500°C. for approximately 8 hours, producing a completely oxidized ash. Three-hundred-milligram aliquots of pulverized ash from each crucible are weighed and transferred to stainless-steel planchets for counting.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Second half 1961	August 1962
Calendar year 1962	November 1963
Calendar year 1963	September 1964
First half 1964	March 1965
Second half 1964	September 1965
First half 1965	March 1966

3. National Reactor Testing Station July–December and Calendar Year 1965[5]

Health and Safety Division
U. S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodic sampling of ground and surface waters, milk, wheat, and air. The locations at which these samples are taken are shown in figure 4. The results of the analysis of these samples are shown in table 10.

[5]Summarized from "Environmental Monitoring Report No. 17, Third and Fourth Quarters and Annual Summary 1965." U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

Offsite water monitoring

Low-level liquid wastes from various operating facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly. Most of these samples are taken from an area southwest of the NRTS, the prevalent direction of underground water flow. During 1965, 64 samples were collected on a semiannual basis from 32 sampling stations. The analytical results indicated no significant change from concentrations recorded during 1964. The average concentrations of alpha and beta emitters were no more than 4 percent and 9 percent of the AEC standards, respectively. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define

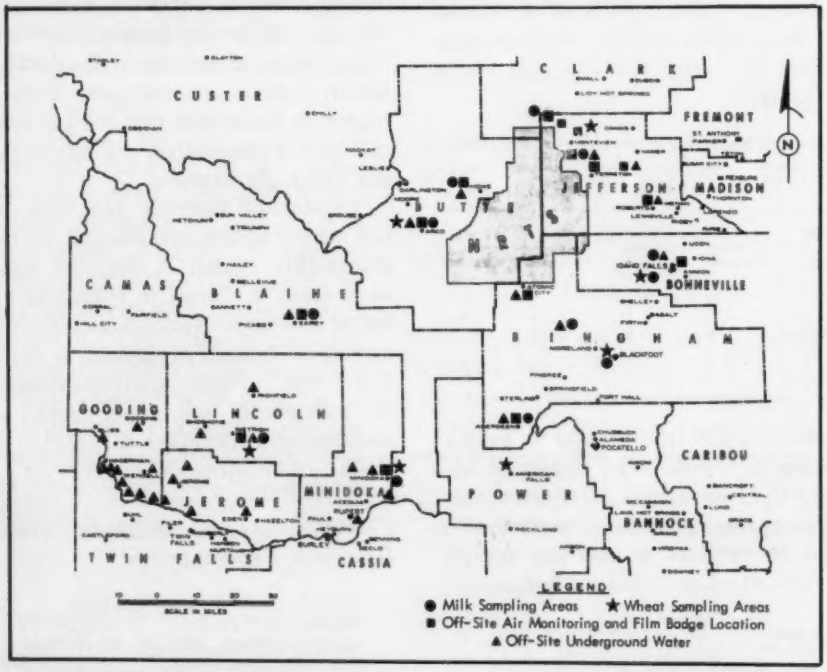

Figure 4. Environmental monitoring stations, National Reactor Testing Stations

Table 10. Environmental monitoring data for the National Reactor Testing Station, July–December and calendar year 1965

Type of sample and units	July–December 1965						Calendar year 1965			
	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample	Number of stations	Maximum activity of single sample	Average activity per sample	AEC standard
Offsite underground water, pCi/liter	32	Semiannual	Alpha Beta	3 6	4 17	<4 8	32	4 20	<4 <9	100 100
Onsite production well water, pCi/liter	22	Biweekly	Alpha Beta	3 6	7 52	3 8	22	7 100	<4 <10	3,000 3,000
Offsite air, pCi/m³	12	Continuous	Beta-gamma Iodine-131	1.6 3.6	56 12	<6 <4	[a]15	56 12	<4 <4	100 100
Offsite milk, pCi/liter	12	Monthly	Iodine-131 Strontium-90	20 1.5	50 22	<21 <11	12	[b]63 24	<23 <13	100 200
Offsite area monitoring badges, mR	12	Monthly	Gamma	10	<10	<10	[a]15	<10	<10	170/yr

[a] Changed from 15 stations to 12 in April of 1965.
[b] This was the highest concentration measured at routine bulk sampling points. A concentration of 310 pCi/liter was the highest level observed in raw milk collected at individual farms.

possible sources of contamination. During 1965, 435 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were no more than 0.2 percent and 0.4 percent of the AEC standards, reflecting no change from the previous year.

Offsite air monitoring

Normal operations of the present radiotelemetry system calls for hourly reports by each station. The reporting instruments and functions are:

1. Ion chamber: This instrument measures ambient radiation levels in mR/hr.
2. GM counters: HV–70 filter paper which collects airborne particulates is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity during the day and another measures the decay of the activity collected the previous day.
3. Scintillation counter: Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity collected by the carbon cartridge is measured hourly by the scintillation counter and is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the sum of the average concentrations of gaseous iodine–131 and particulate activity in the atmosphere was less than 8 percent of the AEC standard during 1965.

Offsite milk monitoring

Routine monthly analyses of iodine–131 and strontium–90 concentrations in milk were conducted during 1965. During the latter part of May, significant concentrations of iodine–131 were detected in the Idaho Falls area Grade A milk. Consequently, an intensive milk sampling program was initiated during the period May 25 through June 20, 1965. The highest concentration measured during this period was 310 pCi/liter. This increase in radioactivity was attributed to fallout from the Chinese nuclear test on May 14, 1965.

Of the 144 routine radioiodine analyses, only 10 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 10, the average iodine–131 levels, including the May through June samples, do not exceed 23 percent of the AEC standard. Strontium–90 concentrations in the same 144 samples showed a maximum concentration of 24 pCi/liter or 12 percent of the AEC standard with an average value of only 13 pCi/liter or 7 percent of the AEC standard.

Offsite area monitoring badges

Offsite film badges were collected monthly during 1965. The maximum radiation dose measured by film at a single location for the

entire year was <120 mR of gamma radiation, based on 12 film changes and a detection limit of 10 mR gamma on each film. For the purpose of calculating the maximum does, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location.

Evaluation of the airborne effluent data from reactor operations in 1965 indicates that the actual offsite gamma dose from NRTS operations was less than 2 mR. This is less than two percent of natural background radiation. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100 to 150 mR/yr.

Wheat monitoring

Monitoring of wheat for radionuclides continued in 1965. In the eight samples analyzed, strontium–90 levels ranged from 11 to 37 pCi/kg with an average of 26 pCi/kg. Cesium–137 levels varied from 60 to 118 pCi/kg with an average of 88 pCi/kg. Analyses for manganese–54 in eight wheat samples collected in the fall of 1965 showed no activity above the detection limit of 100 pCi/kg. The average concentration of manganese–54 in 1964 wheat samples was 790 pCi/kg. This decrease may possibly be attributed to different weather conditions and fallout patterns during the two years under consideration. Although no guide pertaining to wheat has been established, the data indicated that local wheat could not be a significant contributor to the radiation dose received by local consumers.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1961	June 1962
Calendar year 1962	June 1963
Calendar year 1963	September 1964
January–June 1964	March 1965
July–December 1964	September 1965
January–June 1965	March 1966

4. Oak Ridge Area July–December 1965[6]

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 5) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 6). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

[6] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area," compiled by the Applied Health Physics Section of the Health Physics Division, Oak Ridge National Laboratory.

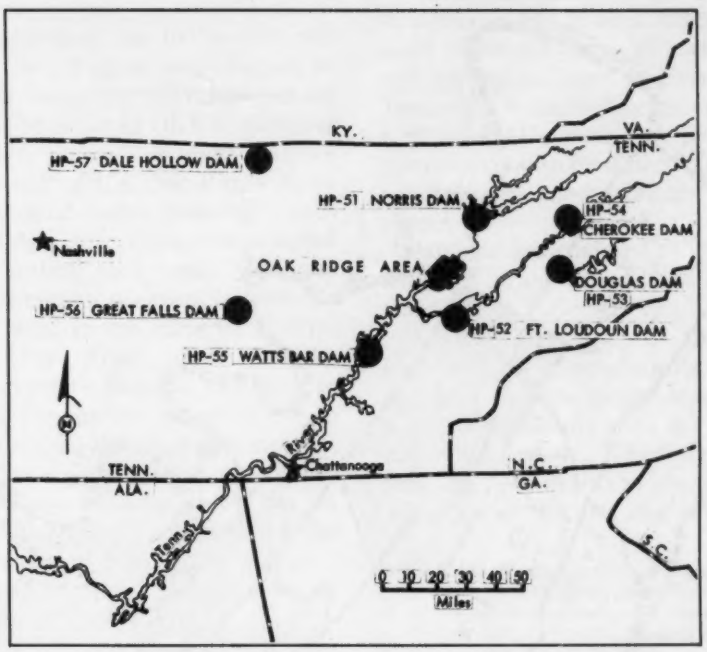

Figure 5. Remote air monitoring stations, Oak Ridge Area

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 11 and 12. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

Table 11. Long-lived gross beta particulate activity in air Oak Ridge area, July–December 1965

Perimeter stations (see figure 5)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard	Perimeter stations (see figure 6)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard
HP-31	26	0.08	0.08	HP-51	26	0.08	0.08
HP-32	26	0.09	0.09	HP-52	26	0.08	0.08
HP-33	26	0.07	0.07	HP-53	26	0.09	0.09
HP-34	26	0.09	0.09	HP-54	26	0.08	0.08
HP-35	26	0.09	0.09	HP-55	25	0.09	0.09
HP-36	182	0.13	0.13	HP-56	25	0.08	0.08
HP-37	26	0.07	0.07	HP-57	26	0.08	0.08
HP-38	26	0.11	0.11	HP-58	22	0.09	0.09
Average		0.09	0.09	Average		0.08	0.08

Table 12. Long-lived gross alpha particulate activity in air Oak Ridge area, July–December 1965

Perimeter stations (see figure 5)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard	Perimeter stations (see figure 6)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard
HP-31	26	0.005	0.25	HP-51	26	0.003	0.15
HP-32	26	0.008	0.40	HP-52	26	0.003	0.15
HP-33	26	0.005	0.25	HP-53	26	0.003	0.15
HP-34	26	0.005	0.25	HP-54	26	0.004	0.20
HP-35	26	0.010	0.50	HP-55	26	0.003	0.15
HP-36	182	0.017	0.85	HP-56	26	0.002	0.10
HP-37	26	0.005	0.25	HP-57	26	0.003	0.15
HP-38	26	0.005	0.25	HP-58	22	0.005	0.25
Average		0.008	0.40	Average		0.003	0.15

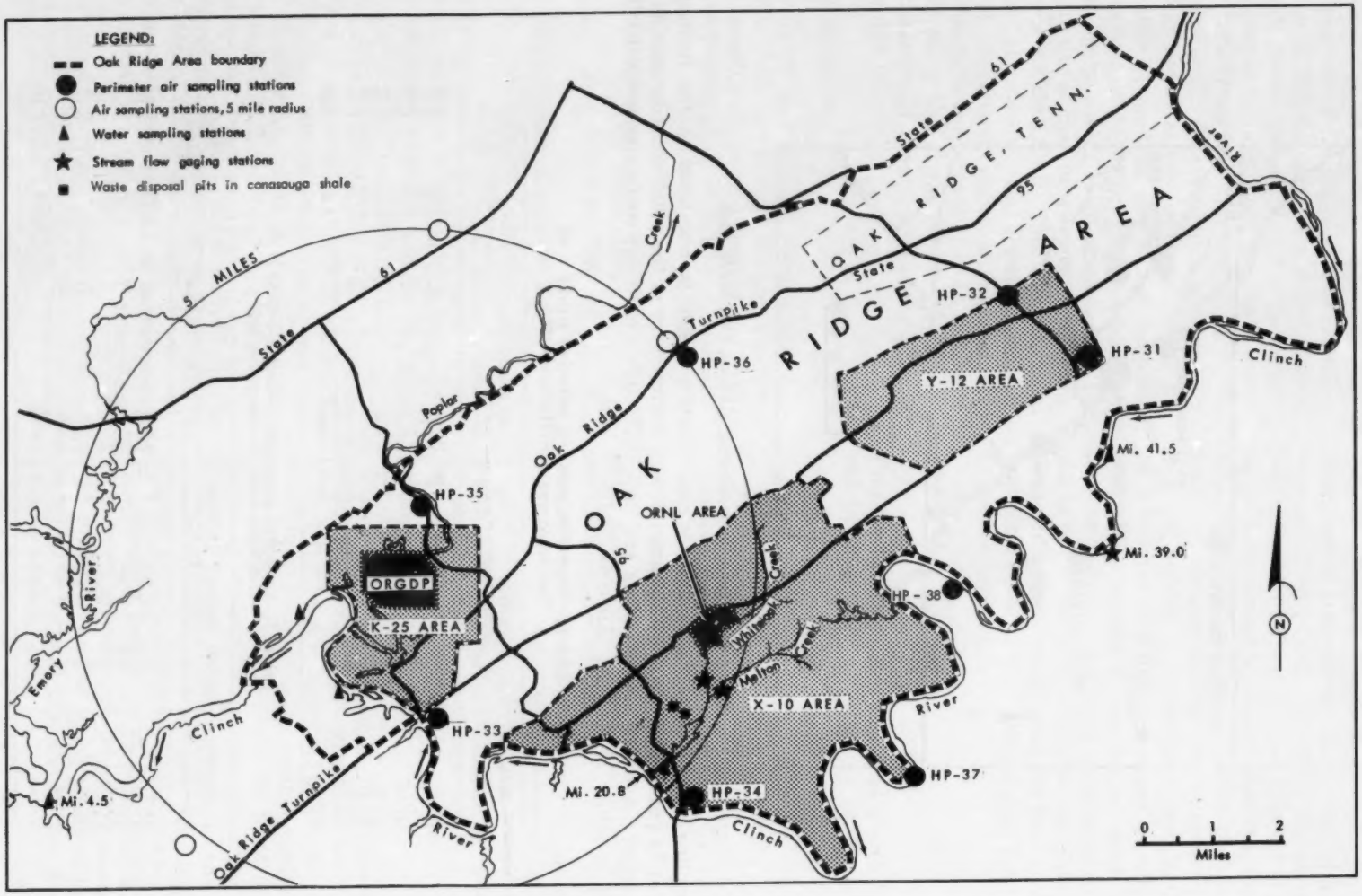

Figure 6. Oak Ridge Area environmental sampling locations

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge Area. Four stations, located more remotely with respect to Oak Ridge Operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge Area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of these radionuclides in raw milk are given in table 13.

Table 13. Radionuclides in raw milk, Oak Ridge area July–December 1965

Radionuclide and location	Concentration, pCi/liter		
	Maximum	Minimum [a]	Average
Iodine-131			
Immediate environs	19	<10	6.1
Remote environs	15	<10	5.9
Strontium-90			
Immediate environs	50	6.3	23
Remote environs	33	17	23

[a] Minimum detectable concentration of iodine-131 is 10 pCi/liter. In averaging, one-half of this value, 5 pCi/liter, was used for all samples showing a concentration less than 10 pCi/liter.

Water monitoring

Large-volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC standards. The radioactivity in White Oak Creek is measured, and values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Steam-gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, uranium, and the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The averages are given in table 14. No uranium was detected in Clinch River water samples during this period.

Table 14. Concentrations of major radionuclides in the Clinch River, July–December 1965

Radionuclide	Average concentration, pCi/liter		
	Location on Clinch River [a]		
	Mile 41.5 (Upstream)	Mile 20.8 [b] (Outfall)	Mile 4.5 (Downstream)
Strontium-90	0.5	0.5	1.3
Cerium-144	0.2	<0.1	0.3
Cesium-137	0.5	0.3	1.0
Ruthenium-106	3.2	4.2	6.1
Cobalt-60	ND	1.3	1.8
Zirconium-niobium-95	ND	<0.1	<0.1
Gross beta	4.5	13	10

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River (see figure 6).

[b] The concentrations at mile 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

ND, none was detected.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 15 in terms of mR/hr.

Discussion of data

The average air contamination level for gross beta activity, as shown by the continuous air monitoring filter data (table 11), for both the immediate and remote environs of the plants (figures 1 and 2) was less than 1 percent of

Table 15. External gamma radiation levels, Oak Ridge area July–December 1965

Location	Average dose rates (mR/hr)
Solway Gate	0.010
Y–12, East Portal	0.010
Newcomb Road	0.012
Gallaher Gate	0.012
White Wing Gate	0.011
Average	0.011

the AEC standard for populations in the neighborhood of a controlled area. This value is approximately one-third of that for the first half of 1965 and is no higher than the average of those measured in other areas of the United States and reported by the U.S. Public Health Service Radiation Surveillance Network for this period.

The average air contamination levels for gross alpha activity, as shown by the continuous air monitoring filter data (table 12), for the immediate and remote environs of the plants were 0.40 percent and 0.15 percent, respectively, of the AEC standard for natural uranium for application to populations in the neighborhood of a controlled area.

The average concentration of iodine–131 in air in the immediate environs of the plants was 0.11 pCi/m^3. This is approximately 0.011 percent of the AEC standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine–131 in raw milk in the immediate and remote environs of the Oak Ridge Area were 6.1 pCi/liter and 5.9 pCi/liter, respectively. These values fall within the limits of FRC Range I if one assumes the average intake per individual to be 1 liter of milk per day.

The average concentration of strontium–90 in raw milk for both the immediate and remote environs of the controlled area was 23 pCi/liter. This level falls within FRC Range II for transient rates of daily intake of strontium–90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tennessee) were 13 pCi/liter and 10 pCi/liter, respectively. These values are 0.34 percent and 0.50 percent of the weighted average AEC standards. The average concentration of transuranic alpha emitters in the Clinch River at mile 20.8 was 0.04 pCi/liter which is approximately 0.001 percent of the weighted average AEC standard.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC standard for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge Area was 0.011 mR/hr, which is approximately the same as that level measured in the early period prior to Oak Ridge operations.

Conclusion

Surveillance of the radioactivity in the Oak Ridge environs indicated that the major part of the radioactivity detected continues to be the result of fallout from weapons testing. While some low-level radioactivity is being released to the environment from plant operations, the resulting concentrations in both the atmosphere and surface streams of the Oak Ridge environment are well below established AEC standards for the neighboring population.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1962	September 1963
1963	July 1964
January–June 1964	January 1965
July–December 1964	July 1965
January–June 1965	January 1966

Section V. Technical Notes

CESIUM-137 AND STRONTIUM-90 IN A DAIRYLAND ENVIRONMENT

E. R. Wykes[1]

A study was conducted during 1964 and 1965 to obtain information concerning cesium–137 and strontium–90 in milk, soil, root mat, and grasses or hay. The objective was to determine, in these media, (a) the relative abundance of these radionuclides, and (b) the ratios of cesium–137 to strontium–90. Five farms at the Elk River, Minnesota, milkshed were chosen for this study. The area concerned covers approximately 65 square miles, and it was assumed that no geographic variability of fallout distribution existed. Monitoring data indicate that controlled releases by the Rural Cooperative Power Association (RCPA) Elk River Reactor have not contributed detectable amounts of radioactivity to farms surrounding the reactor. General farming practices were similar among the farms; thus, variations that might be induced by different farming practices would be minimal.

The locations of the five farms studied are shown in figure 1. Most of the area is covered by glacial deposits that are primarily loose sand and pebbles. Farm D is located on an old Mississipi River flood plain; but here, as elsewhere in the area, the topsoil contains a considerable amount of fine-to-medium-grained loose quartz sand.

In choosing the farms, four topographical areas were considered: (a) level field, (b) lowland swamp, (c) upland uncultivated pasture, and (d) wooded area used for pasture. All of the farms in the study had at least two, and one farm had four, of these features. The characteristics of the individual farms are shown in table 1.

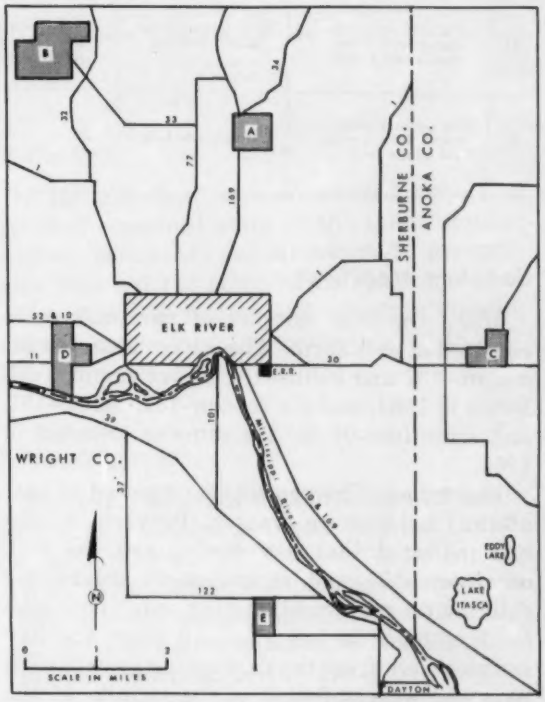

Figure 1. Location of farms

Samples were collected during the 9-day period June 9 through June 17, 1964, and the 11-day period June 15 through June 25, 1965.

[1] Mr. Wykes is supervisor, Radiation Control Unit, State of Minnesota Department of Health, Minneapolis, Minnesota 55440.

Table 1. Characteristics of five farms in the Elk River, Minnesota, milkshed

Farm code	Type of farm	Geology	Collection point	Description	Feed	Daily production (pounds)	Herd
A	Uncultivated pasture, swamp, cultivated fields	Sandy, rocks and pebbles, small quartz grains in soil	1 2 3	Lowland swamp grass Upland pasture grass Lowland hay field	Summer Silage, Corn fodder, Pasture Winter Corn, Oats, Hay, Meal	550	21 Holsteins
B	Uncultivated pasture, swamp, cultivated fields, woods	Very sandy soil	4 5 6 7	Upland pasture grass Lowland swamp grass Upland alfalfa field Upland forest area	Summer Screening, Silage, Pasture Winter Screening, Silage, Hay, Concentrate	100	35 Holsteins
C	Cultivated fields, swamp, woods	Brown sandy soil	9 10 11	Lowland forest area Lowland hay and alfalfa field Lowland hay field (marsh)	Summer Hay, Silage, Corn Winter Hay, Alfalfa, Corn	950	32 Holsteins
D	Level lowland, cultivated fields, some uncultivated land	River terrace, flood plain, hard soil, considerable quarts	8 15 16	Lowland alfalfa field Lowland alfalfa field Lowland wooded area	Summer Hay, Grain, Screening Winter Silage, Corn, Hay, Screening	800	27 Holsteins
E	Hilly pasture, cultivated fields, 3-year-old alfalfa fields	Rolling sandy hills	12 13 14	Upland alfalfa field Upland pasture Lowland marsh area	Summer Pasture, Silage, Hay, Concentrate Winter Silage, Hay, Concentrate	800	40 Jerseys

Sampling procedures

Milk. One-liter samples of raw milk were collected at each farm. These were analyzed for cesium–137 and iodine–131 in five samples collected in 1964, and for cesium–137, iodine–131, and strontium–90 in five samples collected in 1965.

Vegetation. The vegetation consisted of hay, alfalfa, and pasture grasses. Previous studies had indicated that hay contributed the bulk of cesium–137 and strontium–90 intake for cattle, with grain contributing only about one-tenth as much as hay (*1*). All grass and hay samples were from the first spring growth each year and were collected in the vicinity of the soil-sampling sites. The grass and hay samples were analyzed for cesium–137 and strontium–90.

Soils. Sampling sites were selected on the basis of topography and undisturbed ground. Samples were collected only from permanent pastures and fields uncultivated for a minimum of 3 years. At each site, for each year, a total of five surface samples were taken from the corners and center of a 10-foot square, and combined into a composite sample. Subsurface (2 to 6 inches below the surface) sample composites were also taken from the same square. All composited soil samples were analyzed for cesium–137 and strontium–90.

Root mat. The 1964 root mat samples were taken after the vegetation was cut 1 inch above the ground, and consisted of plant root, plant stem, and some decayed vegetation that unavoidably remained on the surface of the soil. However, the greater part of the sample consisted of the live roots of the vegetation. In 1965, all plant stems and decayed vegetation were removed before root mat collection, and all the soil was separated from the samples by hand and by washing in the laboratory. The root mat was composited for each farm and analyzed for cesium–137 and strontium–90.

Laboratory procedures and results

Cesium–137 was determined by gamma spectroscopy. Samples were counted at least 100 minutes with a sodium iodide scintillation crystal and multichannel analyzer.

Strontium–90 determinations were made by radiochemical procedures after suitable preparation of the various types of sample.

Table 2 shows the results of the cesium–137 analyses in all media except milk. Table 3 shows the results of strontium–90 analyses in the same media, and the cesium–137 to strontium–90 ratios for the averages of these media for all the farms. The concentrations of cesium–137, strontium–90, and iodine–131 in the milk samples are presented in table 4.

Table 2. Cesium-137 in root mat, grass, and soil from permanent pastures and fields, 1964 and 1965

Collection point	Concentrations in pCi/kg							
	Root mat		Grass		Surface soil		Subsoil	
	1964	1965	1964	1965	1964	1965	1964	1965
Farm A	7,700	4,900						
1			3,000	1,400	4,100	2,300	350	120
2			2,800	1,400	1,600	1,600	48	30
3			1,200	5,600	960	850	190	140
Farm B	6,200	15,000						
4			4,200	4,600	1,600	1,300	50	30
5			21,000	22,000	1,800	2,000	50	40
6			1,400	660	640	1,600	170	140
7			2,600	4,900	490	720	50	30
Farm C	4,200	3,000						
9			1,100	400	2,200	2,000	90	30
10			1,400	460	960	1,500	240	150
11			1,900	340	1,300	1,300	360	150
Farm D	5,800	13,000						
8			1,800	1,400	960	950	220	90
15			2,300	810	690	1,100	170	250
16			2,800	860	960	1,000	70	10
Farm E	4,400	4,800						
12			1,400	530	800	1,400	240	330
13			4,200	720	1,700	1,700	240	120
14			680	330	2,100	2,900	580	200
Average	5,700	8,100	3,300	2,900	1,400	1,500	200	120

Table 3. Strontium-90 in root mat, grass, and soil from permanent pastures and fields, 1964 and 1965

Collection point	Concentrations in pCi/kh							
	Root mat		Grass		Surface soil		Subsoil	
	1964	1965	1964	1965	1964	1965	1964	1965
Farm A	3,300	2,600						
1			5,800	1,400	1,900	880	150	250
2			3,200	2,300	640	680	10	71
3			1,400	1,200	400	380	160	94
Farm B	3,700	5,600						
4			3,200	3,500	1,000	700	8	8
5			6,800	3,300	240	1,200	22	74
6			2,000	2,300	420	720	66	74
7			3,000	2,300	150	220	8	10
Farm C	2,800	1,900						
9			1,100	1,300	870	990	66	52
10			1,700	2,100	630	770	97	120
11			2,100	1,000	920	590	140	110
Farm D	4,300	5,800						
8			2,200	1,800	540	400	82	70
15			3,100	550	510	700	100	150
16			1,300	930	440	50	28	63
Farm E	2,600	1,900						
12			2,300	2,100	480	550	81	130
13			4,200	1,600	770	500	60	70
14			610	480	600	390	180	54
Average	3,300	3,600	2,800	1,800	650	640	80	90
Ratio of averages $^{137}Cs/^{90}Sr$	1.73	2.25	1.18	1.56	2.16	2.34	2.5	1.33

Table 4. Radionuclides in raw milk from five Elk River farms, 1964 and 1965

Collection point	Cesium-137 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)	
	1964	1965	1964	1965	June 17, 1964	June 24, 1965
Farm A	150	63		24	ND	11
Farm B	260	270	No	47	ND	14
Farm C	110	97	anal-	21	12	ND
Farm D	150	100	yses	13	ND	24
Farm E	180	89		17	ND	11
Average	170	120		24	ND	15

ND, not detectable, or less than 10 pCi/liter.

Conclusions

In the dairyland area considered here, the root mat contained more of the fallout radionuclides cesium–137 and strontium–90 per unit mass than did the other media studied.

The ratio of cesium–137 to strontium–90 between sample media varied between 1.18 and 2.50.

Acknowledgments

The contributions of the following staff members of the Minnesota Department of Health are acknowledged:

E. L. Watzl, who made the field observations and collected samples in 1964 and 1965;

R. J. Wedlund, who assisted Mr. Watzl in sample collections during 1965;

F. C. Labernik, who, with assistance from personnel in the engineering laboratory, prepared and analyzed all the samples.

REFERENCE

(*1*) MINNESOTA DEPARTMENT OF HEALTH and UNIVERSITY OF MINNESOTA. Factors influencing strontium–90 in milk from the Brainerd, Minnesota, milkshed, PHS Publication No. 999–R–1. U.S. Department of Health, Education, and Welfare, PHS, Division of Radiological Health (December 1962).

REPORTED NUCLEAR DETONATIONS, AUGUST 1966

One U.S. nuclear test at the Nevada Test Site was announced by the Atomic Energy Commission in August 1966. This was a low-yield test conducted underground on August 10.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

POLONIUM–210 IN TOBACCO, CIGARETTE SMOKE, AND SELECTED HUMAN ORGANS. *E. Ferri* and *E. J. Baratta. Radiological Health Data and Reports, Vol. 7, September 1966, p. 485–488.*

By means of a "smoking machine" to simulate actual smoking, it was found that polonium–210 concentrations in inhaled tobacco smoke accounted for about 11 to 30 percent of that found in the total product, depending on the type of filter used. Analyses of human tissues indicated that the lung, blood, and liver, in that order, of smokers contained more polonium–210 than the corresponding organs of nonsmokers.

KEY WORDS: blood, bone, cigarettes, heart, human tissues, lead–210, liver, lung, muscle, polonium–210, radionuclides, radium—226, smoking machine, spleen.

MAINE'S EXPERIENCE WITH A STATE-OPERATED PERSONNEL MONITORING PROGRAM FOR RADIATION WORKERS. *J. W. Fuller. Radiological Health Data and Reports, Vol. 7, September 1966, pp. 489–492.*

In a 10-year program of monitoring exposures of radiation workers, Maine's Department of Health and Welfare found increasing acceptance of its free film badge services. Results of findings are outlined. Examination of over 5,000 film badges in 1965 indicated that exposure of the great majority of individuals was relatively low. Periodic radiological health surveys of installations that used independent film badge services indicated that no exposures to individual workers exceeded 100 milliroentgens per week.

KEY WORDS: exposure, film badge, Maine, radiation, radionuclides, X-ray.

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SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^3	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^3	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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